

Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

APPLICATION OF LINEAR PROGRAMMING TO FARM  
MANAGEMENT ANALYSIS: INTENSIVE BEEF  
GRAZING SYSTEMS

---

A thesis presented in partial fulfilment  
of the requirements for the degree of  
Master of Agricultural Science in Farm  
Management at Massey University.

---

Alan F. McRae •  
September 1975.

TABLE OF CONTENTS

TABLE OF CONTENTS	<u>Page</u> ii
LIST OF FIGURES	vii
ACKNOWLEDGEMENTS	ix
ABSTRACT	x
CHAPTER ONE: MOTIVATION, OBJECTIVES AND OUTLINE OF STUDY	
1.1 Introduction	1
1.1.1 Intensive Grazing Systems	1
1.2 Motivation for This Study	3
1.2.1 The Systems Research Concept	4
1.2.2 The Usefulness of Mathematical Systems Models	9
1.3 Objectives of the Study	10
1.4 Thesis Outline	10
CHAPTER TWO: THE BEEF GRAZING SYSTEM	
2.1 Introduction	12
2.2 Components of the Grazing System	12
2.2.1 Interaction of the System Components Over Time	14
2.2.2 Uncertainty Within the System	17
2.2.3 Summary of System Components	18
2.3 Research Work on the Components of a Beef Grazing System	18
2.3.1 Pasture Production and Grazing Management	19
2.3.2 Animal Production and Feed Requirements	22
2.3.3 The Use of Research Data in This Study	24
2.4 System Modelling Studies on Beef Production in New Zealand	25
2.4.1 The Profitability Studies of Lattimore (1970) and Lowe (1971)	25
2.4.2 The Simulation Study of Wright, Vallance and Nicol (1973)	27
2.5 A Dairy Farming Systems Modelling Study	29

	<u>Page</u>
2.6 The Comparison of Linear Programming with Simulation as a Technique for Studying Grazing Systems	30
2.7 The Model Used	31
2.8 Summary	32
 CHAPTER THREE: PASTURE GROWTH	
3.1 Introduction	33
3.2 Factors Affecting the Regrowth of Pasture	33
3.2.1 The Pasture Regrowth Curve	33
3.2.2 Changes in the Growth Curves Throughout the Year	34
3.2.3 The Effect of Management on Pasture Growth	34
3.2.4 The Effect of Grazing Animals on Pasture Production	39
3.2.4.1 The Number of Animals Grazed	39
3.2.4.2 The Treading Effects of Animals	40
3.2.4.3 The Effect of Faeces	41
3.3 Pasture Production Data Used in This Study	42
3.3.1 Assumptions Involved in Defining Pasture Regrowth	45
3.4 The Pasture Production Model	46
3.4.1 Pasture Production Possibilities Within the Model	46
3.4.2 The Structure of the Model	51
3.4.3 The Representation of the Grazing Process by the Model	53
3.4.3.1 The Length of Spell Between Grazings	53
3.4.3.2 The Height to Which Pasture is Grazed	54
3.4.4 Comment on the Length of Spell Options Within the Pasture Production Model	56
3.5 DM Production Associated with the Pasture Production Activities	58
3.6 Limitations in the Pasture Production Model	61
3.7 Annual DM Production from the Pasture Production Model	63



## 3.8 Summary

Page  
65

## CHAPTER FOUR: ANIMAL PRODUCTION

4.1	Introduction	66
4.2	The Intake of Grazing Beef Animals	66
4.2.1	Factors Affecting the Potential Daily Intake of Grazing Beef Animals	69
4.2.2	Factors that Affect the Shape of the Function Relating Available Pasture to Intake	70
4.3	The Representation of Animal Intake Within the Model	75
4.4	The Conversion of Feed Intake into Animal Production	77
4.4.1	The Energy Value of Feed	77
4.4.2	Systems for Expressing Feed Requirements	80
4.4.2.1	Published Feeding Standards	82
4.5	Feeding Standards Used in this Study	86
4.5.1	Calculation of Feed Requirements	86
4.5.1.1	The Relationship Between Animal Liveweight and Maintenance Requirement	86
4.5.1.2	The Relationship Between Animal Liveweight Level of Performance (L.W.G.) and Production Requirement	87
4.5.1.3	The Effect of Pasture Quality on Feeding Standards	91
4.5.1.4	A Consideration of Compensatory Growth	92
4.5.1.5	The Significance of Intake (Liveweight Gain) Restrictions in the Feed Requirements Model	93
4.6	Summary	94

## CHAPTER FIVE: MODEL EXPERIMENTATION AND RESULTS

	<u>Page</u>
5.1 Introduction	96
5.2 Animals Considered in the Study	96
5.3 The Stocking Rate Decision	97
5.3.1 BEEF Production Systems	97
5.3.2 Maximization of Stocking Rates for BEEF Activities	99
5.3.3 Conditions that Prevent Further Increases in Stocking Rate for BEEF Systems	104
5.3.3.1 BEEF 1	104
5.3.3.2 BEEF 2	104
5.3.3.3 BEEF 3	105
5.3.3.4 BEEF 4	105
5.4 Discussion on Maximum Stocking Rates for BEEF Systems	105
5.5 Grazing Management Plans	108
5.5.1 Comparison of Grazing Management Plans for BEEF1 and BEEF2	120
5.5.2 Comparisons of Grazing Management Plans that Maximize Stocking Rate for BEEF2 with BEEF3 and BEEF4	121
5.6 Relating Grazing Management Plans to Farmer Practice	
5.6.1 Uses of the Model for Grazing Manage- ment Studies	125
5.7 Supplementary Feeding	126
5.7.1 Hay and Silage Making Activities	126
5.7.2 Supplementary Feeding Activities	128
5.7.3 Experimentation with Supplementary Feeding Possibilities	129
5.7.4 Discussion on the Increased Stocking Rate Due to Supplementary Feeding	131
5.7.5 Further Experimentation Possible With the Model Including Supplementary Feeding Possibilities	132
5.8 Summary	133

CHAPTER SIX:	EVALUATION OF STUDY	<u>Page</u>
6.1	Introduction	<u>134</u>
6.2	Verification of the Model	135
6.2.1	Pasture Production	135
6.2.2	Animal Production as a Function of Intake	136
6.3	Analysis of Farm Management Problems Using L.P. Models	138
6.4	Evaluation of Study	141
APPENDIX ONE:	THE PASTURE PRODUCTION MODEL	143
APPENDIX TWO:	BEEF ACTIVITIES	148
APPENDIX THREE:	SHADOW PRICES ASSOCIATED WITH THE MAXIMUM STOCKING RATE FROM BEEF2	150
APPENDIX FOUR:	THE SUPPLEMENTARY FEEDING MODEL	153
BIBLIOGRAPHY		157

LIST OF FIGURES

<u>Fig.</u>		<u>Page</u>
1.1	Two Aspects of Systems Analysis in Relation to Systems Synthesis	7
2.1	Components of a Beef Production System	13
2.2	Interrelationships Between Variables that Affect Production in the t'th Period of the Year	16
2.3	The Evolutionary Development of Grazing Management Systems	
3.1	Generalized Pasture Regrowth Curve	35
3.2	Representation of Hypothetical Management Decisions	37
3.3	Pasture Regrowth and Daily Increments in DM/ha., After HIGH and LOW Defoliation	44
3.4	Pasture Production After Grazing HIGH and LOW in Period (t)	62
3.5	Grazing Pattern for Maximum Annual DM Production from the Model	64
4.1	Actual Daily Intake/Head as a Function of Available Feed/Head	68
4.2	A Relationship Between Pasture Available/Animal and Intake/Animal	72
4.3	A Generalized Representation of the Results of Reardon (1975)	74
4.4	Partitioning of Feed Energy Within the Ruminant	78
4.5	Partitioning of Available Energy	79
4.6	Comparison of the Feeding Standards of Lowe (1971), Jagusch (1973), and Those Shown in Table 4.1; for Three Levels of Liveweight Gain, and Three Liveweights	85
4.7	Maintenance Requirement as a Function of Liveweight	88

4.8	Maintenance Requirement as a Function of (Liveweight) <sup>0.75</sup>	88
4.9	Liveweight Gain as a Function of Production Intake/(Liveweight) <sup>0.75</sup>	90
5.1	Patterns of Liveweight Achieved by Animals in Beef Production Systems at Maximum Stocking Rates	101
5.2	Daily Liveweight Gain Achieved	102-103
5.3-5.6	Period Feed Requirements for BEEF 1, 2, 3 and 4, at Maximum Stocking Rates	109-112
5.7-5.10	Grazing Management Plan for BEEF 1, 2, 3 and 4	115-118
5.11	The Fate of 27 ha. Grazed LOW in Period (1)	124

ACKNOWLEDGEMENTS

The author would like to formally express his gratitude to Professor Robert J. Townsley, Professor of Agricultural Economics and Farm Management, Massey University, for supervision of the study. The time spent by Professor Townsley assisting the author with interpretation of results and presentation of this thesis is particularly appreciated.

The author benefited from discussions with several other staff members at Massey University, especially Dr. A. Wright and Dr. A.W.F. Davey.

The staff of the Massey University Computer Unit have been particularly helpful.

The Ministry of Agriculture and Fisheries have been tolerant employers throughout the somewhat extended duration of this study. Their financial assistance is gratefully acknowledged.

The author is appreciative of the efficient manner in which Mrs. Hilde Godenho typed the bulk of this thesis. Thanks are also due to Miss Cathey Harris for typing parts of the thesis, and Mr. Rick Godenho for assistance in presentation of many of the text diagrams and tables.

The author would also like to thank many others, friends and flatmates, who helped make the period of this study a more enjoyable time than it may have otherwise been.

Finally, thanks are due to the author's parents for the interest they have shown, and the encouragement they have offered in this and earlier studies.

ABSTRACT

In the absence of quantitative data from the practical farm situation, Linear Programming (L.P.), was used as a framework for collecting research information on an intensive beef grazing system.

Three hundred pasture production activities were defined so that pasture was available for grazing at two grazing severities in each of 30 periods throughout the year, after a range of spelling lengths. Seventeen supplementary feedmaking activities allowed hay or silage to be made over the late spring, early summer period. Supplementary feed could be fed out in any period of the year subject to the constraint that per animal intake of supplementary feed did not exceed maintenance requirement.

Animals considered by the model are Friesian bulls purchased at three months of age, and 100 Kg. liveweight, and grazed within the system for 12 - 18 months, until they reached a liveweight of 380 Kg. Animal requirements were calculated as a function of liveweight and level of liveweight gain. These requirements were expressed in terms of pasture dry matter per animal, and were adjusted for assumed changes in the available energy (M.E.) content of pasture throughout the year.

Although the model could not be verified in relation to the real-life situation, due to lack of quantitative data, the capability of the model for solving farm management problems was investigated. An iterative procedure for solving the stocking-rate decision was developed, and results presented and analysed. The use of the model for investigation of beef farm management problems was discussed.