THE DEVELOPMENT OF STOCKING RATE MODELS FOR THREE VELD TYPES IN NATAL

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DECLARATION

This thesis is the result of the author's original work except for assistance acknowledged, or unless specifically stated to the contrary in the text. It has not been submitted for any degree or examination at any other University.

J.R. TURNER

Creation has no bounds.

I have come to know GOD.

It is to my parents, Bob and Patricia, who have instilled in me entrepreneurial ideals, and to my wife Meryn, who is helping me to live them
– to whom I dedicate this work.

TABLE OF CONTENTS

PART 1

INTRODUCTION

PART 2

THE DEVELOPMENT OF A STOCKING RATE MODEL FOR THE LOWVELD

PART 3

THE DEVELOPMENT OF A STOCKING RATE MODEL FOR THE TALL GRASSVELD

PART 4

THE DEVELOPMENT OF A STOCKING RATE MODEL FOR THE SOUR SANDVELD

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Both the continued funding from the Department of Agriculture is gratefully acknowledged and the generous assistance of Gallagher-Poldenvale in the initial stages (who gave generous discounts on many of the materials required for the electric fencing).

I would once again like to express my gratitude to the stalwarts of this project, those who have given selflessly and generously of themselves to further the understanding and knowledge we have of one of our precious resource - veld.

<u>Sites 1 & 2</u> (on Llanwarne Estates, Magudu): Janie and Rita Bender and Boet and Jackie Oosthuisen, and the Andersons who made Llanwarne Estates available.

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ABSTRACT

The overall objective was to develop stocking rate models for three veld types, namely the Lowveld, the Southern Tall Grassveld and the Natal Sour Sandveld, in Natal. Sub-objectives were to determine the 1) residual herbage mass at the end of the summer, 2) residual herbage mass at the end of winter and 3) individual animal performance under grazing conditions, and the effect of stocking rate on these three variables. Multiple linear regression component models were successfully developed to meet all three of the sub-objectives for each of the three veld types.

Results show that veld condition is an extremely important factor determining animal production from veld, and that stocking rate on veld in good condition could possibly be double that on veld in poor condition. Stocking rate did not have the expected impact on individual animal performance in the summer, although it did have an important moderating influence under any particular set of environmental conditions. Stocking rate did, however, have a marked effect on herbage production and therefore on herbage availability in winter and so also on the ability to overwinter cattle without having to supply additional supplementary feed. Stocking rate in summer therefore had a major indirect effect on animal production in the winter. Carryover of residual herbage from one year to the next is probably not as important in these veld types as in some other parts of the country.

LIST OF ABBREVIATIONS

General list of abbreviations:
ADG = Average daily gain
AP = Animal performance
CMG = Cumulative mass gain (of animals over a time period)
DG = Gain on a particular day (derived from fitted curves)
DH = Disc height
DM = Disc meter
GD = Grazing day
HM = Herbage mass
IAP = Individual animal performance
LSU = Large Stock Unit
RF = Rainfall
S = Stocking Rate
VCI = Veld Condition Index

Veld types are often, particularly in tables and figures, abbreviated as follows:
LV = Lowveld
TG = Tall Grassveld
SS = Sour Sandveld

Stocking rate treatments are often, particularly in tables and figures, abbreviated as follows:
L = Light stocking rate treatment
M = Moderate stocking rate treatment
H = Heavy stocking rate treatment

Camps have been numbered and referred to as follows in the text and tables.

The number is preceded by a suffix L, M or H to denote to which stocking rate treatment they were assigned i.e. light, moderate or heavy stocking rate.

The number denotes to which group of camps they were assigned at a particular site. Groups of camps at a particular site were, as far as possible, treated identically, except for stocking rate.

The largest number of camps at a particular site is 12 and they would therefore be numbered as follows:

	Stocking rate treatment		
	light	moderate	heavy
Group 1	L1	M1	H1
Group 2	L2	M2	H2
Group 3	L3	M3	H3
Group 4	L4	M4	H4

Seasons. The terms summer and winter are often used loosely.

When summer is referred to it may indicate either:

the period over which grass production occurred in a particular season, or

the period over which grass can potentially grow outside of the true winter months (June, July and August) should there be no limiting environmental factor.

It is not used in its strictest sense to mean the months of December, January and February.

When winter is referred to it may indicate either:

the period over which no grass production occurred in a particular season, or

the period over which grass will not generally grow outside of the true summer months (December, January and February) should there be a limiting environmental factor.

It is not used in its strictest sense to mean the months of June, July and August.

PART 1

INTRODUCTION

CHAPTER

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Beef is one of the major agricultural commodities produced in Natal. Most of this beef is produced extensively or semi-extensively. Veld is therefore, by and large, the basis for beef production in Natal.

Most of the extensive and semi-extensive beef production systems in Natal are situated in 6 of the 17 veld types described by Acocks (1975) for Natal. These are the Lowveld (10), the Arid Lowveld (11), the Valley Bushveld (23), the Highland Sourveld (44), the Southern Tall Grassveld (65) and the Natal Sour Sandveld (66). These veld types cover about 55% of Natal (Edwards, 1974).

The potential of Highland Sourveld for beef production has been investigated at the nTabamhlope and Kokstad Research Stations. There is, however, only one other research station in Natal involved in research on animal production from veld, namely Dundee Research Station. There are no facilities in the other four veld types for research on beef production from veld.

When this project was conceived, it was decided that the least well researched of the major veld types should receive attention. The co-operative nature of the trials ruled out investigation of Valley Bushveld because it falls largely into KwaZulu. The Highland Sourveld has received relatively a lot more attention than either the Lowveld (and Arid Lowveld), the Tall Grassveld and the Sour Sandveld and so the programme was focused on these. They comprise 33% of Natal (Edwards, 1974) or 60% of the important extensive and semi-extensive beef production areas of Natal.

The primary aims of the project were to determine

a. the effects of stocking rate on veld condition;

b. the effects of stocking rate on animal performance; and

c. the potential of veld in different conditions within each of these veld types for animal production.

The first aim requires long-term data and thus this aim can be addressed here only speculatively on the basis of utilisation intensity and the possible consequences this may have on veld condition. The last two aims can be addressed fairly confidently here recognising, however, that additional data will allow greater refinement of the models which have already been produced.

CHAPTER 2

MATERIALS AND METHODS

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MATERIALS AND METHODS

Turner (1988, 1988b, 1988c) reviewed at length factors affecting carrying capacity and methods for estimating carrying capacity. The data from the 1986/87 season from these trials were also analysed (Turner, 1988). A review of literature and the general materials and methods for this project have therefore already been described. On this basis it was judged that the inclusion, and therefore the repetition, of this material in the body of this dissertation, was unnecessary, particularly for those familiar with this earlier work. However, in order that this dissertation stand alone and for readers not familiar with this earlier work, the description of the Materials and Methods have been included as an appendix (Appendix 1).

Because of seasonal differences in environmental conditions, and because all of the procedures described by Turner (1988) are not essential for the analyses in this dissertation, some minor modifications have been made to the text. It should be noted that it is the procedures that were intended which are outlined in Appendix 1. Seasonal environmental and treatment differences forced changes in management (or deviations from the intended management), particularly in the pattern of winter grazing and in the spring burning treatments. These changes were applied differently at each site according to conditions at each site. Decisions to change the intended management were, however, not haphazardly taken. Criteria on which decisions were based were defined.

The reasons for any changes made to the procedures used will really only be clear once the results are considered. Moreover, the changes have not necessarily been consistent from season to season because of the changing environmental conditions from season to season. A description of each deviation from the intended management in the general description on the materials and methods (Appendix 1) would therefore be extremely cumbersome and tedious, and would probably serve only to confuse the reader. This will therefore be undertaken in the presentation of the results because it will be more clear to the reader why these changes (or deviations from the intended management) were necessary.

CHAPTER 3

SOME CONCEPTS FOR STOCKING VELD

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Stocking rate is the area of land allotted to each specified animal unit (Booysen, 1967). It may be expressed either as the number of animals per unit area (LSU/ha) or as the reciprocal of this (ha/LSU) (Danckwerts, 1986). The former is generally used for pasture and the latter for veld (Edwards, 1981). The relationship between the number of animals on an area of land and the unit ha/LSU is non-linear whereas relationship between the number of animals on an area of land and the unit LSU/ha is linear (Danckwerts, 1989). For analyses, therefore, the unit LSU/ha is preferred (Danckwerts, 1989).

Whether a farm is overstocked, correctly stocked or understocked depends on the number of animals carried in relation to the grazing capacity of the veld (Danckwerts and King, 1984). Grazing capacity is a function of the veld, while stocking rate is manager dependent (Danckwerts, 1989). The rate at which veld and pasture is stocked is one of the most important factors, and probably the most important single factor under the control of the manager, which affects production, profitability and financial stability in livestock enterprises (Edwards, 1981).

Often the same assumptions and principles applied to stocking pastures are applied to stocking veld. For example, the model developed by Jones and Sandland (1974), which was developed primarily from data collected from pastures, has gained wide acceptance, even for veld (e.g. Danckwerts and King, 1984). There are, however, many aspects in which pastures and veld differ and which require different emphasis in decisions on stocking rate.

3.1 CHARACTERISTICS OF VELD WHICH INFLUENCE DECISIONS ON STOCKING RATE

There are several characteristics of veld which influence decisions on stocking rate.

a. The production potential of veld (in terms of both the quantity and quality of herbage produced) is generally very low. The rate at which veld is stocked is therefore usually of the order of 1 to 0.1 or less Large Stock Units (LSUs) per hectare (or of the order of 1 to 10 ha or more per LSU).

b. There are large seasonal fluctuations in herbage production, influenced primarily by rainfall (Rutherford, 1978; Barnes and McNeill, 1978). However, the carry-over effect of the treatment from the previous season also plays an important role (e.g. Danckwerts, 1989). (The need to measure the effects of stocking rate on herbage production and vigour and therefore on the condition of the veld, has been strongly appreciated. Experiments to measure these effects are generally costly and measurements are required over long periods. There is therefore little quantitative data on the effects of stocking rate on veld condition. There is, however, much observational support for the effects of different stocking rates on veld.)

c. In many veld types there are large changes in the quality of veld through the year (Bransby, 1981; van Niekerk, Hardy, Mappledoram and Lesch, 1984). Because quality of veld is subject to large seasonal variation, the potential level of individual animal performance is also subject to large seasonal variation. It is therefore widely applied practice to supplement grazing animals with a mineral lick in the summer months and, particularly in the mixed and sourveld areas, to supplement animals with protein and/or energy licks, in the winter months. Animal performance on veld, particularly in the winter, would be strongly influenced by the level of supplementation.

3.2 CHARACTERISTICS OF VELD-BASED ANIMAL PRODUCTION SYSTEMS WHICH INFLUENCE DECISIONS ON STOCKING RATE

There are several characteristics of veld-based animal production systems which influence decisions on stocking rate.

a. Animals are usually run on veld year round. The accumulation of sufficient forage in the summer to carry animals through the following winter is therefore essential.

b. The <u>long-term</u> stability of the enterprise is usually the primary aim for veld-based animal production systems. Generally, therefore, high importance is attached to the carry-over effects of treatment from one season to the next.

c. In practice it is difficult to alter stocking rates and production systems to fit seasonal fluctuations in herbage production.

d. Costs are often difficult to allocate to particular components of veld-based animal production systems because 1) the production cycle is annual and not seasonal (as in pastures), 2) the treatment carry-over effects from one season to the next cannot easily be assessed (for example the effect of winter nutrition on conception rates in the following summer) and 3) the impact of a decision taken on one component of the system on any other components of the system cannot easily be assessed.

3.3 A BASIS FOR STOCKING VELD IN ANIMAL PRODUCTION SYSTEMS ON VELD

There would appear to be two important points which emerge from these characteristics of veld and veld-based animal production systems which affect decisions for stocking veld.

a. There should <u>never</u> be a need to buy in supplementary feed or radically alter the production system because of "drought". Excessively high stocking rates on veld are therefore unacceptable for whatever reason, irrespective of what short-term criterion the suggestion to stock veld heavily is based.

b. Stocking rates for veld-based animal production systems have to be evaluated and viewed holistically in the light of long-term stability and production. It is therefore important to re-evaluate stocking rates regularly in veld-based animal production systems.

3.4 THE CONCEPT OF A "GRASS" SUMMER AND WINTER AND AN "ANIMAL" SUMMER AND WINTER

The periods in the year over which grass growth and animal mass gain, and over which grass dormancy and animal maintenance and mass loss occur, are not the same (although there is often a large overlap as will emerge from later discussion). The results presented in this dissertation will clearly show that the seasons of growth and dormancy for grass always start earlier than the respective seasons of mass gains and mass losses for animals. Therefore, for modelling veld-based animal production systems, there is a need to distinguish between the times over which growth and no growth occurs for grass and over which mass gain and mass loss occurs for animals i.e. for the concept of a "grass" summer and an "animal" summer and for a "grass" winter and an "animal" winter. These terms will be freely used in discussing the data, when they will become more clear.

3.5 A BASIS FOR DEVELOPING STOCKING RATE MODELS FOR THREE VELD TYPES IN NATAL

Animal production systems in the three veld types under evaluation have been observed to have one feature in common: animals are run on veld year round. Although cultivated pastures or crop residues do play an important role on some farms, veld remains the basis for animal production in these areas.

Emphasis is currently being placed on finishing animals on the farm, and if possible, on the veld (Meaker, 1989). Should an alternative method of finishing be required (usually in a feedlot or on pastures), it is still important to obtain good animal performance from the veld and so reduce the length of time and/or the costs of finishing animals during this finishing phase (Meaker, 1989).

Herbage production (or grass growth) in veld occurs primarily in the summer. In the cooler Tall Grassveld and Sour Sandveld, observation has shown that grass will start to "green up" in September and that growth will occur late into April. However, results presented in this dissertation and from previous work (Turner, 1988) show that most of the grass growth occurs in the six months from October to March inclusive. The limitation to growth outside of this period (or between May and August inclusive) appears to be temperature. Good September rains will initiate an "early" spring but any delay in rains from September onwards will result in a "late" spring. In the warmer Lowveld, grass growth will occur at any time during the year provided that there has been sufficient rain. However, rain occurs mostly during the summer months. This therefore confines most of the grass production to the summer period. There is a strong tendency in the Lowveld for the first rain of the season to occur in late the spring. This sometimes delays the start of grass production to as late as December.

The following questions should therefore be addressed in the development of stocking rate models:

1. How much grass can be produced in the summer period on a specific area?

2. Will the grass produced in the summer be sufficient to also see the animals through the winter?

3. What animal production can be expected, particularly during the summer, from a specific area?

PART 2

THE DEVELOPMENT OF A STOCKING RATE MODEL FOR THE LOWVELD

CHAPTER

PART 2

OVERVIEW

In Natal, the Lowveld and Arid Lowveld[1] are encountered primarily in the north-east i.e. Zululand. These two veld types cover areas of approximately 11 342 km² (12,9%) and 624 km² (0,7%) of Natal respectively (Edwards, 1974). The topography varies from almost flat to steep hillsides, although most of the area is reasonably accessible.

The mean annual rainfall varies from less than 600 mm to nearly 800 mm (Shulze, 1982). The seasonal variation in rainfall is large. In very dry seasons, the drier parts may

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[1] The distinction between these two veld types in Natal is not very clear. The difference is probably related mainly to the mean annual rainfall. The sites lie probably in a transition zone between the two. The results will therefore probably be equally applicable to both these veld types in Natal and, for the purpose of this dissertation, they will be regarded as one veld type.

receive as little as 300 mm while in very wet seasons the more moist parts may receive over 1000 mm.

Frost rarely occurs. Winters are therefore mild. As a result grass will grow, following a good fall of rain, even during the winter, although at a slower rate than in the summer.

The Lowveld is a savanna with a large diversity of trees and grasses. Generally a great number of species will occur in an area. The genus *Acacia* is particularly well represented (19 species occur (Moll, 1981) of which *A. burkei*, *A. karroo*, *A. leuderitzii*, *A. nigrescens*, *A. nilotica* and *A. tortillis* are the most widespread and common). However, distinct tree/grass communities (comprising relatively few species) are often seen and result either because of specific soils factors which favour certain species or because of interactions between trees and grasses. For example, in the Lowveld of northern Natal heavy clay soils are usually dominated by an *Acacia nigrescens*-*Setaria woodii* community and sandy soils of granite origin by a *Combretum apiculatum*-*Terminalia sericea*-*Hyperthelia dissoluta* community.

In veld considered to be in good condition, the herbaceous layer in wooded areas (particularly those with an abundance of *Acacia* species) is dominated by *Panicum maximum* and *P. coloratum* while that in open areas is dominated by a tall form of *Themeda triandra*. Degradation under a fairly closed tree canopy usually results in bare ground, while under more open tree canopies and in open areas, in dominance by *Urochloa mossambicensis* and, if degradation is severe, by *Sporobolus smutsii* and *S. nitens*.

Bush encroachment is a big problem. This is probably due to 1) overstocking, 2) an imbalance between grazers and browsers, 3) the discouragement of the use of fire over the last two decades (which has resulted in a near absence of fire in these areas), (Tainton, 1977) and 4) low intensity fires when they do occur (Tainton, pers. comm.).

Beef production is the main source of farm income in these areas. The veld is one of the sweetest of all veld types represented in Natal, except perhaps for parts of the Valley Bushveld (Veld Type 23). Beef is produced almost entirely from veld. Although generally little use is made of licks, additional feed often has to be purchased on many farms during dry years because of overstocking.

In this veld type, the primary objectives for veld management should be 1) to ensure a good productive sward and 2) to ensure that there is sufficient grass to run animals on veld throughout the year, without having to purchase supplementary feed.

Pastures are being increasingly established, particularly under irrigation. In many instances cash crops are being replaced by pastures either because they are proving more lucrative or because there is less risk involved. Where pastures are being established in Lowveld, the primary objective is to increase the carrying capacity of the farm and not to provide a source of high quality forage. The most popular pasture species appear to be Cynodon species (Coast Cross 2, Stargrass and more recently Tifton 78) and Cenchrus ciliarus.

Game is ubiquitous. Income from game, both from venison production and hunting, is becoming increasingly important as this potential is being realised and exploited.

Domestic browsers, and in particular goats, are largely absent. The reasons often put forward for this are that goats 1) are difficult to manage (disease, theft and herding), 2) accelerate veld degradation and bush thickening and 3) will be in direct competition with wild ungulates, in particular the browsers.

Cultivation does occur along the major rivers. The crops that are grown include citrus, sugar cane and cotton. The residues do not form an important source of feed for livestock as do, for example, maize and wheat residues in beef production systems in other veld types in Natal.

CHAPTER 4

RESULTS FROM THE LOWVELD

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RESULTS FROM THE LOWVELD

Two important assumptions have been made in the presentation of results and the development of models for the Lowveld.

a. Game is ubiquitous and moves freely throughout this area, mostly unhindered by game fences. It was not possible to excluded game from the sites. It was also not possible to keep a record of the occurrence of game on the sites. Their impact could therefore not be assessed. The first important assumption, therefore, is that the effect of game was the same on all treatments and that the effect of game will be the same throughout the areas to which the models will be applicable.

b. Tree density has not been included in these models because inadequate data were available. However, the sites were chosen, albeit subjectively, to be representative of the area. The second important assumption, therefore, is that the tree densities were the same in all camps and that the same tree density will occur throughout the areas to which these models will be applicable.

These two assumptions may in certain circumstances, for example in areas that are bush encroached or game fenced, result in some error. The operator should therefore be aware of these assumptions and, through good judgement, adjust for these factors, perhaps erring on the conservative side.

4.1 RAINFALL

Monthly rainfall for Sites 1 and 2 are shown in Figs 4.1 and 4.2 respectively. Also indicated is the expected distribution of rainfall (Shulze, 1982) for the amount received in each particular season. The annual rainfall over the three seasons for the sites situated in the Lowveld is shown in Table 4.1.

Rainfall increased at both Sites over the three seasons. It was about average in the first season and above average for

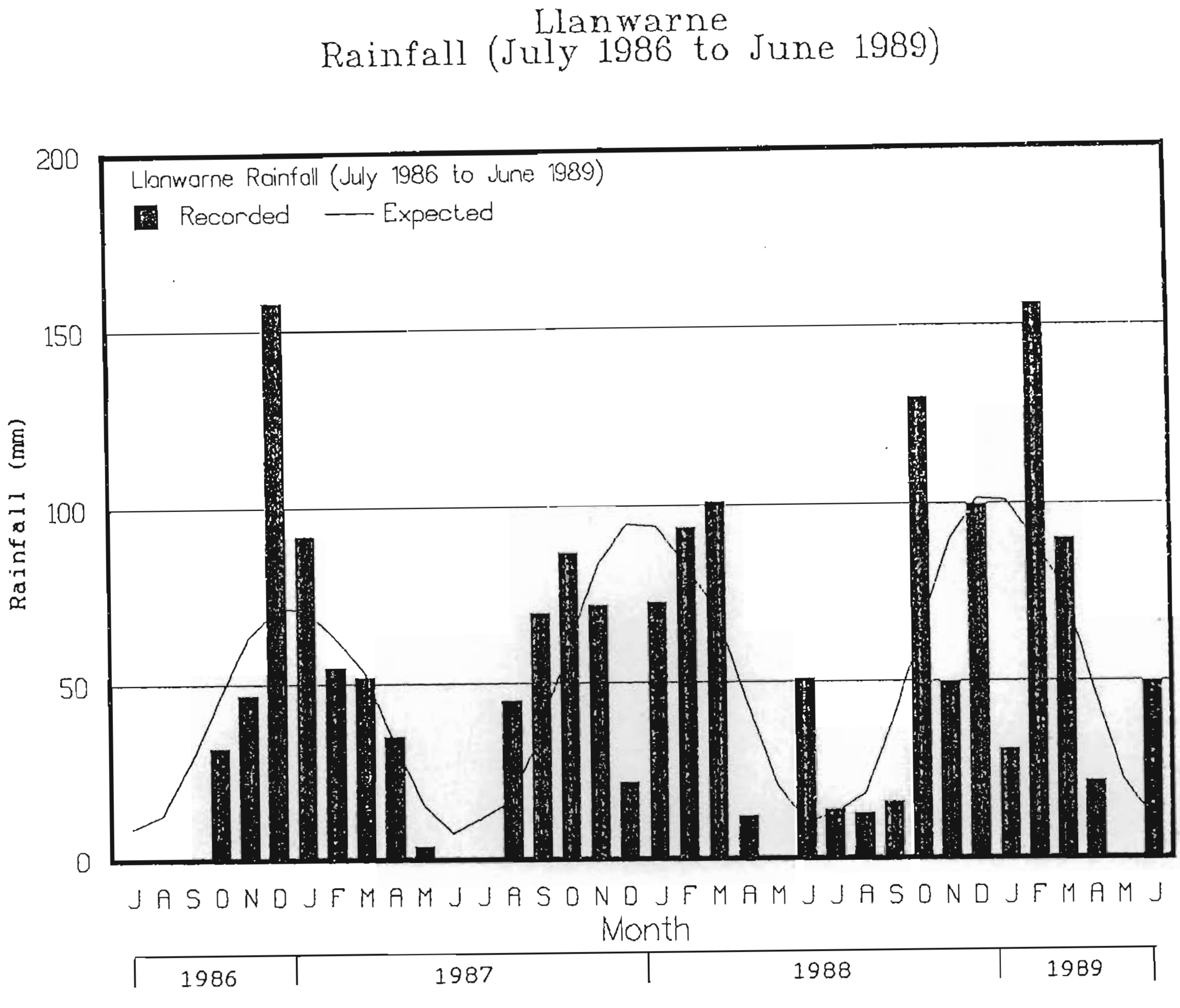


Fig. 4.1. <u>Monthly rainfall at Site 1</u> over the three year experimental period. The solid line indicates the expected distribution of rainfall over the three years, based on mean long-term percentage distribution for each month.

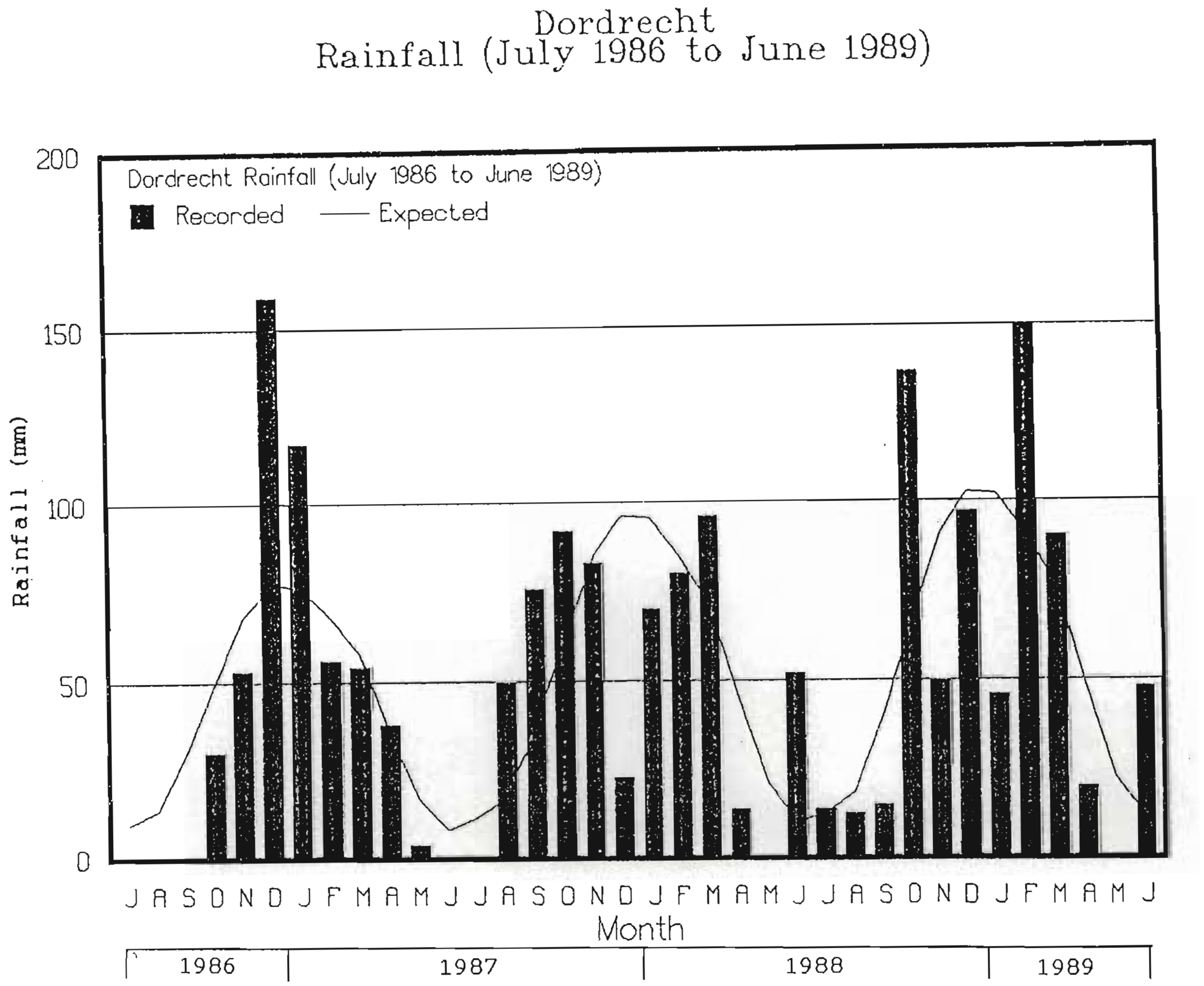


Fig. 4.2. Monthly rainfall at Site 2 over the three year experimental period. The solid line indicates the expected distribution of rainfall over the three years, based on mean long-term percentage distribution for each month.

Table 4.1. Seasonal and average rainfall over the three year trial period and mean long-term rainfall for Sites 1 and 2.

Season	Rainfall (mm)	
	Site 1	Site 2
1986/87	475	511
1987/88	627	636
1988/89	672	680
mean	591	609
mean long-term	518	518

the two subsequent seasons. It should be noted that there was some rain in the second winter.

4.2 VELD CONDITION

Proportional species composition data collected in January 1987 were used to develop indices of veld condition. It has been assumed that there was no change in veld condition over the three seasons under analysis, although some changes may have occurred. On the one hand, with the increasing rainfall over the three seasons under analysis, one may have expected that veld condition may have improved with the good management applied (including stocking at a relatively light rate). On the other hand, the light stocking rate that was applied in these trials is not considered particularly light while the heavy stocking rate that was applied is considered very heavy for this veld type. Thus there is also the possibility that adverse changes may have occurred, particularly in the camps assigned to the heavy stocking rate treatments.

Assessment of these data indicated that only seven grass species occurred with an abundance of over 5% in any particular camp (Table 4.2). These species are Themeda triandra, Panicum maximum, P. coloratum, Digitaria argyrograpta, Urochloa mossambicensis, Sporobolus smutsii and S. nitens. At Site 1 they made up 78% and at Site 2 they made up 67% of the total proportional species composition.

Table 4.2. The proportional species composition of the seven grass species which made up at least 5% of the proportional species composition in any single camp at Sites 1 and 2. (L, M and H are the light, moderate and heavy stocking rate treatments respectively and m = mean.)

Site, Treatment & Camp	Proportional species composition (%)					
	TTR	PMA	PCO	DAR	UMO	SSM+SNI
L1	6	41	5	22	1	1
L2	5	17	20	17	12	9
mL	6	29	12	19	7	5
M1	5	25	6	25	18	8
M2	5	16	22	14	5	6
mM	5	21	14	19	12	7
H1	7	27	15	22	8	6
H2	2	25	13	22	4	10
mH	4	26	14	22	6	8
m(Site 1)	5	25	13	20	8	7
L1	2	30	5	24	12	11
L2	2	19	13	12	7	23
mL	2	24	9	18	10	17
M1	1	8	21	7	14	16
M2	0	11	15	1	5	15
mM	1	9	18	4	10	16
H1	2	6	5	10	9	39
H2	2	23	16	2	15	7
mH	2	15	11	6	12	22
m(Site 2)	2	16	12	9	10	18

TTR = *Themeda triandra*
PMA = *Panicum maximum*
PCO = *P. coloratum*
DAR = *Digitaria argyrograpta*
UMO = *Urochloa mossambicensis*
SSM = *Sporobolus smutsii*
SNI = *S. nitens*

Individually, therefore, other species are likely to have contributed relatively little to herbage production.

4.3 CHANGES IN DISC HEIGHT AND HERBAGE MASS

Mean disc height (DH) from 50 disc meter readings was measured in each camp at three week intervals. The changes in DH for each camp are presented in Figs 4.3 and 4.4 for Sites 1 and 2 respectively. The first data (period 0) were collected on 17 December 1986 and the last data (period 45) on the 19 July 1989. Also indicated in these figures are 1) the rainfall which occurred during every period and 2) whether or not camps were grazed during the period. Disc meter readings relate to each measuring period (which were 3 weeks apart) but rainfall and grazing relate to the interval between measuring periods prior to the period indicated.

It should be noticed that responses in the DH to rainfall were mostly seen at the end of the period over which the rainfall was measured. However, in some instances responses appeared to be delayed to the next recording three weeks later. For example, at Site 1 and for camps of Group 1 (Fig. 4.3a), no rain was recorded during period 7, yet there was an increase in DH. The reason for this is that the rain which fell during a period sometimes fell in the last two or three days of the period. The time during which the grass could respond was therefore short. Hence the appearance of a

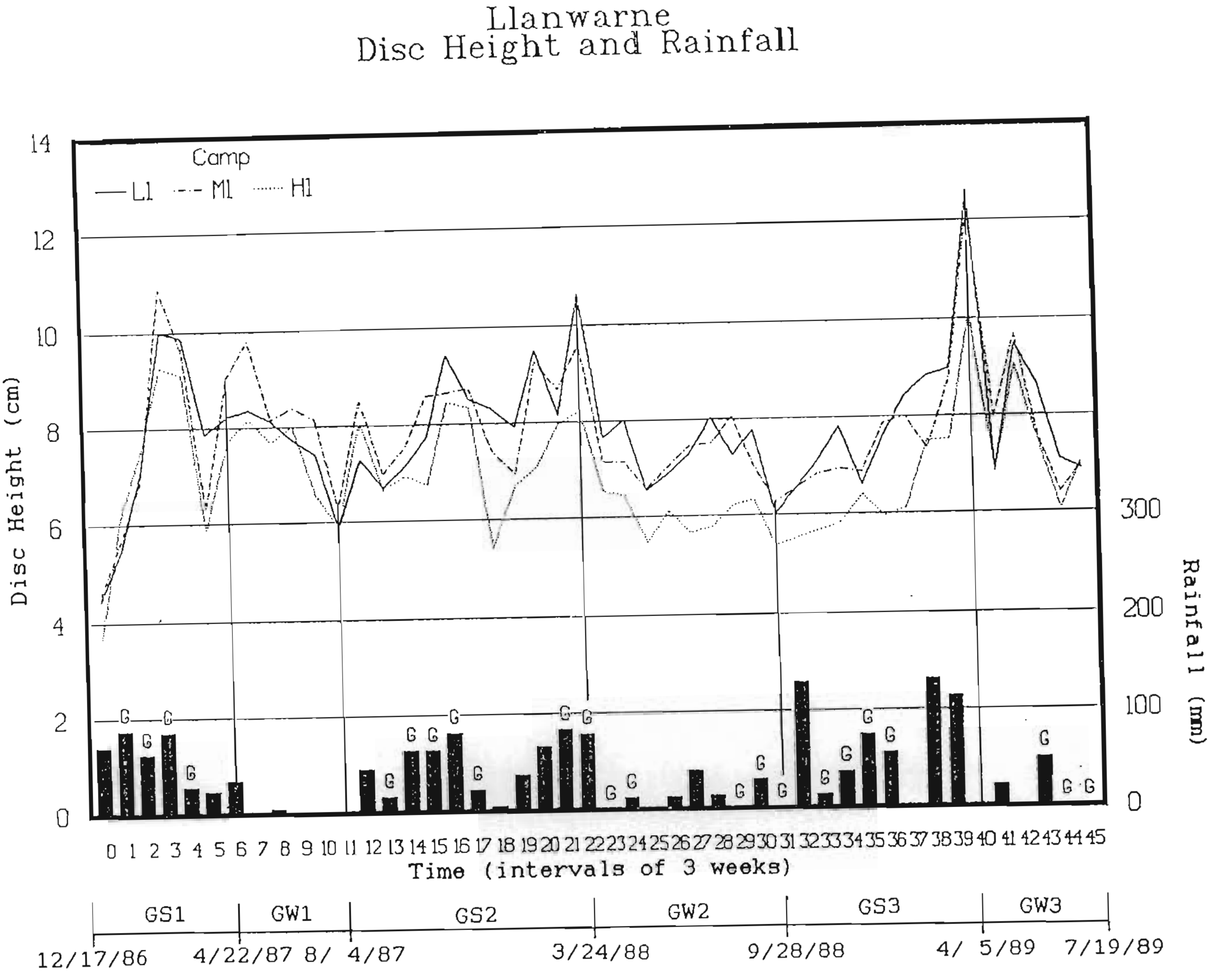


Fig. 4.3a. <u>Disc height (cm)</u> at each measuring period for each camp of <u>group 1 at Site 1</u>. Also indicated is the rainfall (mm) that occurred during each period and the periods during which the group of camps was grazed (G). The vertical lines show the grass summers (GS) and grass winters (GW) (which are labelled below the X-axis). (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

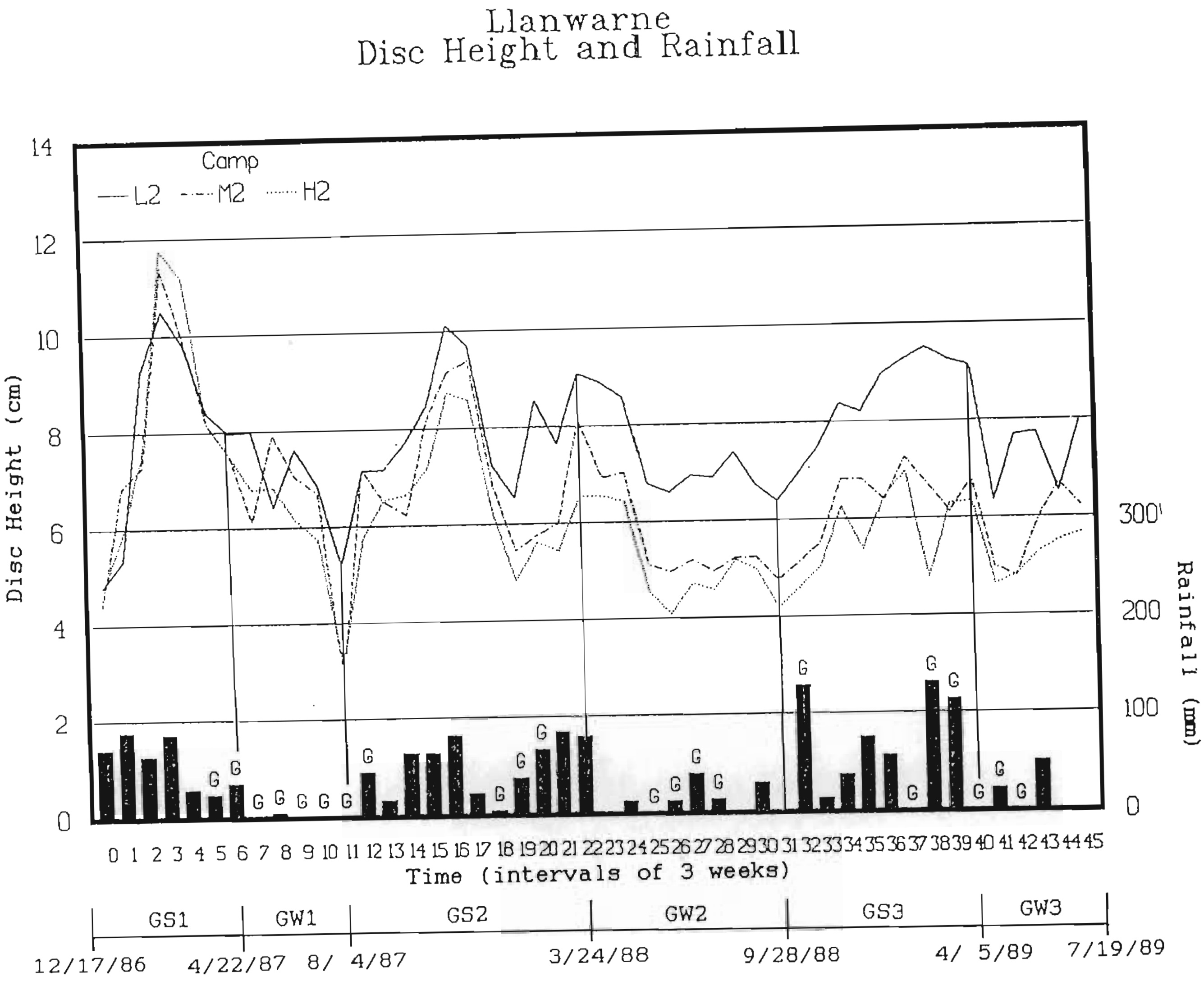


Fig. 4.3b. Disc height (cm) at each measuring period for each camp of group 2 at Site 1. Also indicated is the rainfall (mm) that occurred during each period and the periods during which the group of camps was grazed (G). The vertical lines show the grass summers (GS) and grass winters (GW) (which are labelled below the X-axis). (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

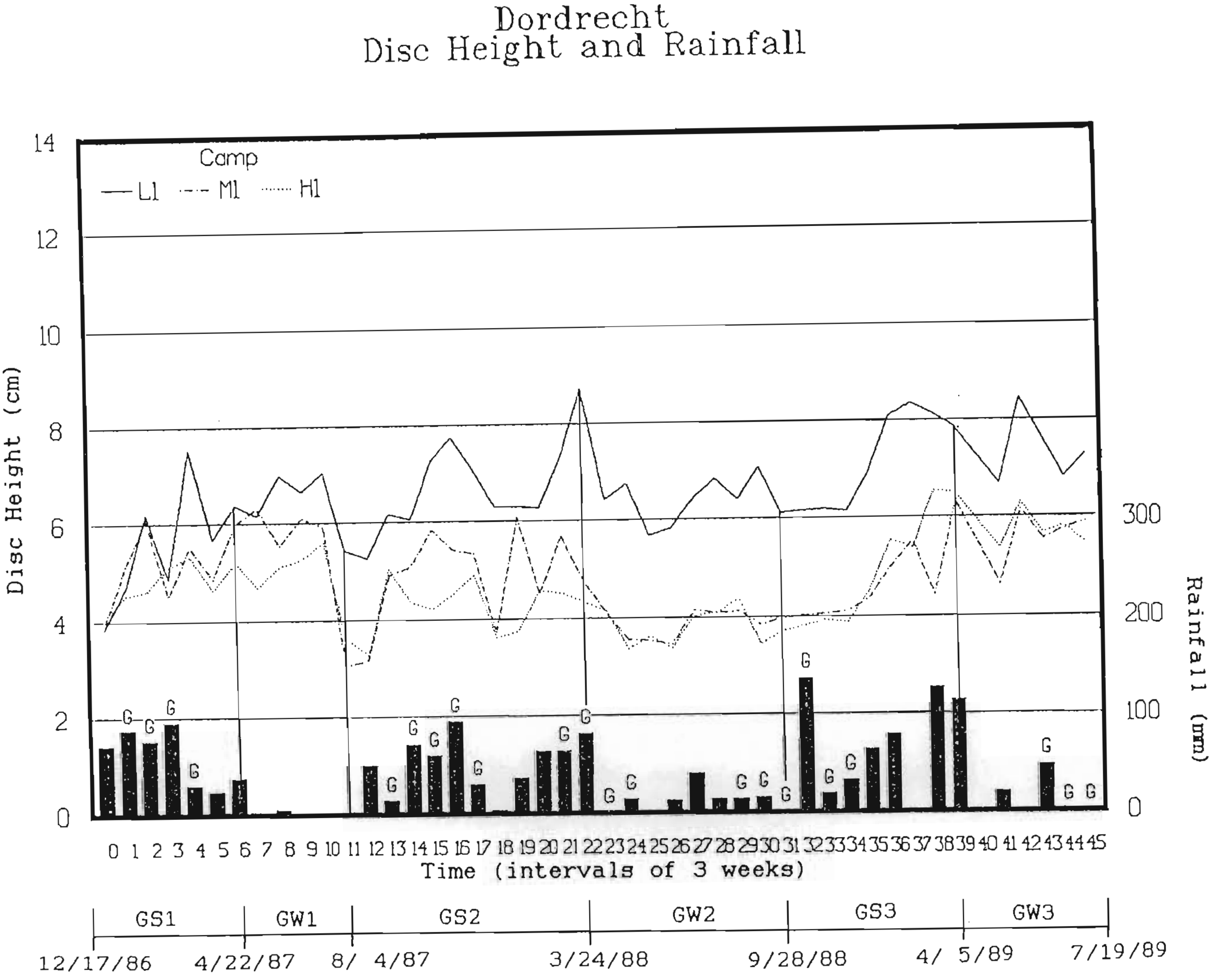


Fig. 4.4a. Disc height (cm) at each measuring period for each camp of group 1 at Site 2. Also indicated is the rainfall (mm) that occurred during each period and the periods during which the group of camps was grazed (G). The vertical lines show the grass summers (GS) and grass winters (GW) (which are labelled below the X-axis). (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

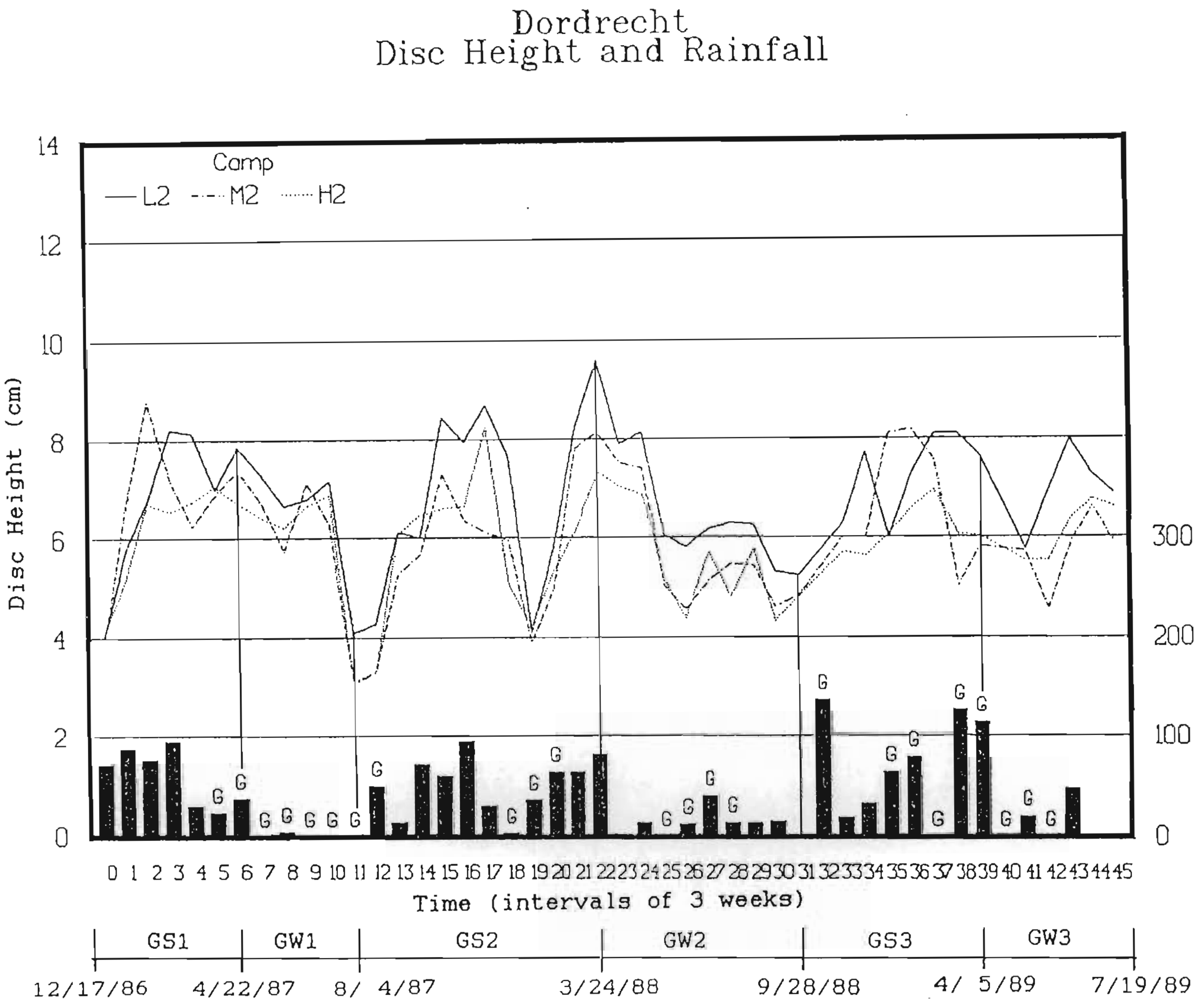


Fig. 4.4b. Disc height (cm) at each measuring period for each camp of group 2 at Site 2. Also indicated is the rainfall (mm) that occurred during each period and the periods during which the group of camps was grazed (G). The vertical lines show the grass summers (GS) and grass winters (GW) (which are labelled below the X-axis). (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

"delayed" response. DM data were not collected frequently enough to be able to determine the carry-over effects of rainfall from one period to another.

Correctly applied, the DM should have been calibrated at each period. Logistically this was not possible. It was therefore calibrated at nine week intervals (see Appendix 1). The intension was to use each calibration curve to estimate the herbage mass (HM) for the specific period for which it was developed and for the period on either side. However, many conceptual and practical difficulties arise from the application of the calibration curves in this way. It was felt that the changes in DH itself reflected realistically the changes in HM over the seasons. It was therefore decided to combine all the data and develop a general calibration curve for the Lowveld, which is as follows:

$$H = 882 + 271D$$

$$r^2 = 0{,}56 \quad **$$

where

H = Herbage mass (kg/ha)

D = Disc height (cm)

Because a single general calibration curve for herbage mass on disc height is being used, the changes in HM will follow an identical pattern to the changes in DH.

The grass summers and winters which were identified for the three seasons (see discussion in Section 3.4) are shown in

Figs 4.3 and 4.4. (DM data were not collected at Site 2 at period 40 for reasons of bad weather. The data used from Site 2 in the models therefore only included that up to the end of period 39 for the third grass summer.) From these figures some general observations may be made.

a. DHs at the end of the grass summers did not show an increase over the three years as one would have expected with the steady increase in rainfall. This would suggest that there has been a steady decrease in vigour of the veld.

b. DH followed closely the pattern of rainfall. In particular, the effect that a mid-summer "drought" (periods 17 and 18) or winter rain (at periods 27/28 and 43) had on DH is very clear. (It should also be noted that animal performance responded to the grass growth which resulted from winter rain. This is discussed later in Section 4.4).

c. The lengths of the grass summers and the grass winters varied from year to year.

d. The effect of stocking rate on HM was particularly marked where veld was both in poor condition and heavily stocked (e.g. camps M2 and H2 in Fig. 4.3b and camps M2 and H2 in Fig. 4.4a).

e. DHs of < 4 cm (or a HM of < 1966 kg/ha) were seldom recorded. (The lowest DH recorded was 2,8 cm or 1640 kg DM/ha.) When such low DHs were recorded, the veld had been grazed to a level consistent with the concept of a grazing cut-off (Turner, 1988).

4.4 CHANGES IN ANIMAL PERFORMANCE

The data for mean animal cumulative mass gains (CMGs) are presented in Figs 4.5 and 4.6 for Sites 1 and 2 respectively. From these data changes in mean individual animal performance (IAP) with time over the 45 time periods (which coincide with those for the disc meter data) are clearly seen. The animal summers and winters (discussed in Section 3.4) which were identified for the three seasons are shown in these figures.

Polynomials were fitted to the CMG data for each stocking rate at each site (Figs 4.7 and 4.8 for Sites 1 and 2 respectively). Stocking rates (LSU/ha) were calculated from the fitted data using the procedure described by Turner (1988). A summary of mean IAP and actual stocking rates applied have been derived from fitted data and are given in Table 4.3.

The following should be noted with respect to IAP in the Lowveld.

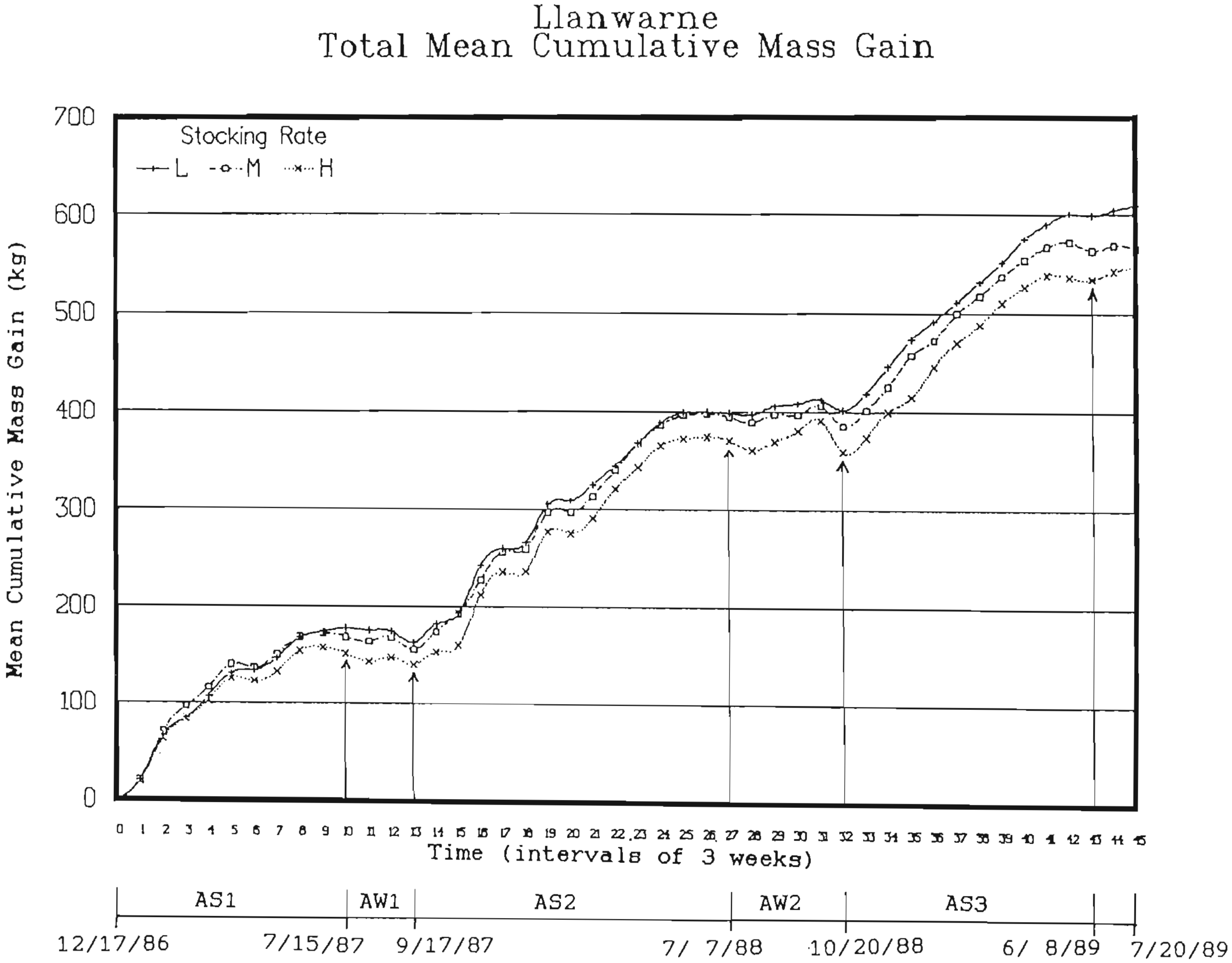


Fig. 4.5. The mean cumulative mass gain (kg) over the three year experimental period at Site 1 for each stocking rate treatments treatment. The vertical arrows show the animal summers (AS) and animal winters (AW) (which are labelled below the X-axis). (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

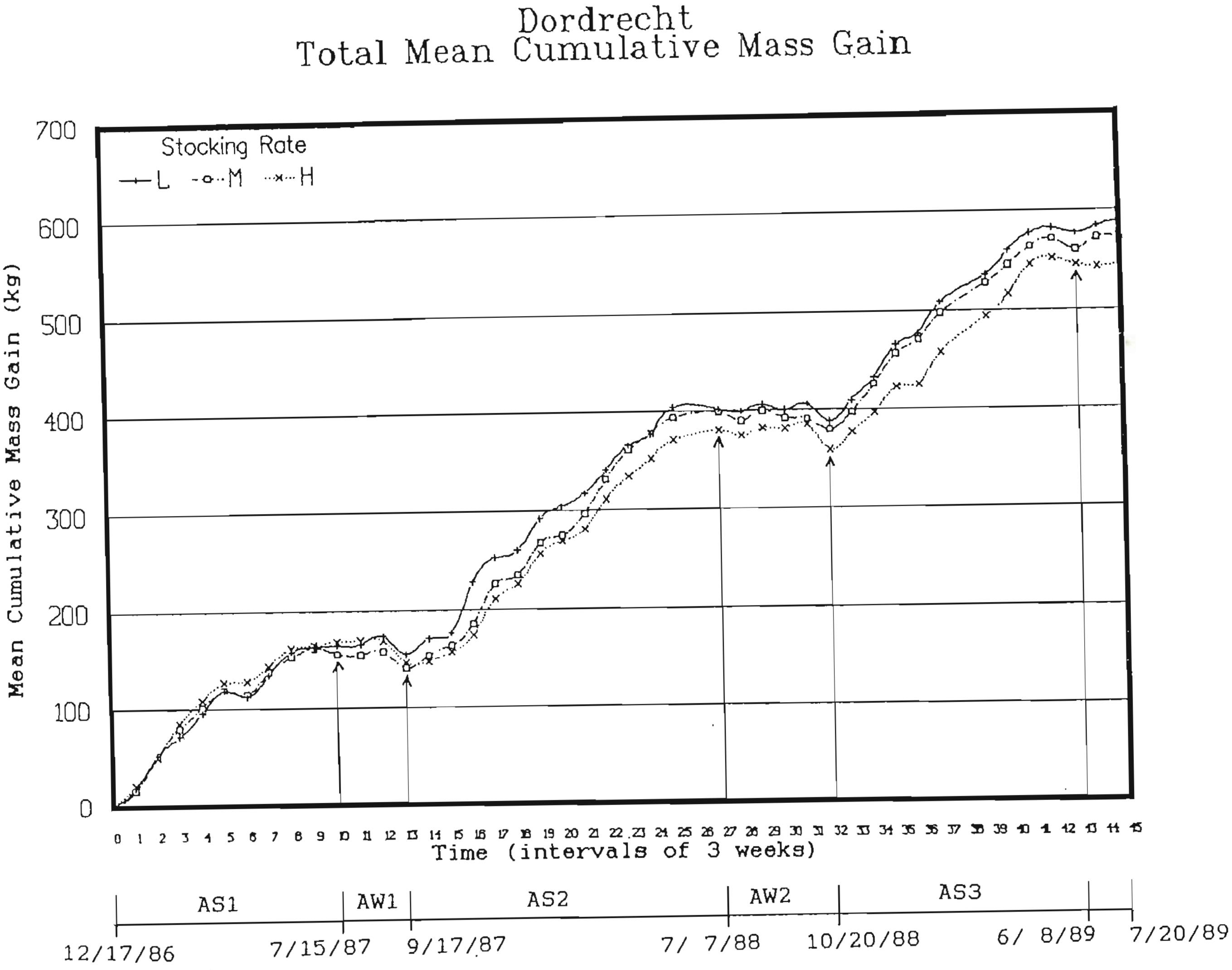


Fig. 4.6. The <u>mean cumulative mass gain (kg)</u> over the three year experimental period at <u>Site 2</u> for each stocking rate treatment. The vertical arrows show the animal summers (AS) and animal winters (AW) (which are labelled below the X-axis). (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

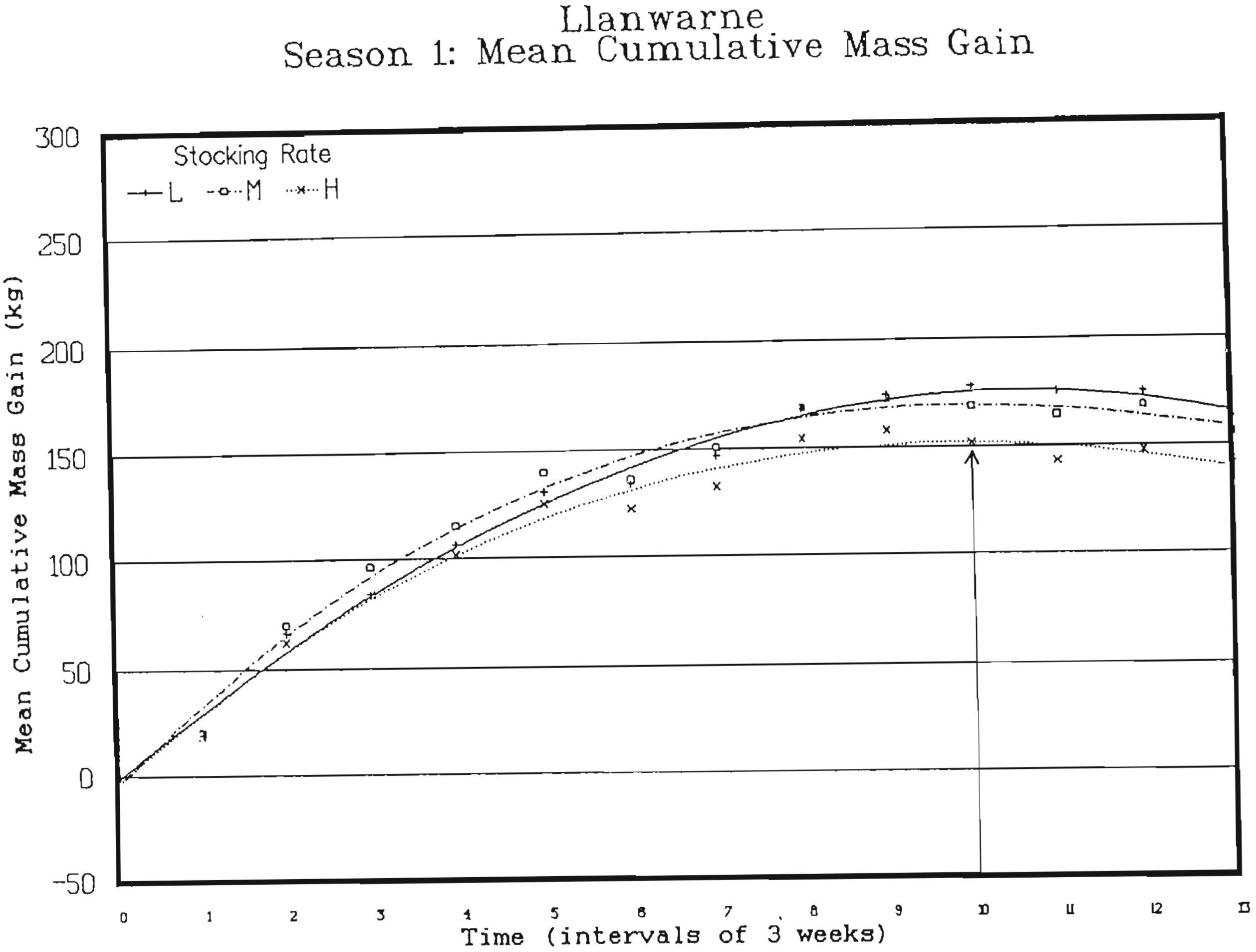


Fig. 4.7a. The fitted mean cumulative mass gain (kg) over the first summer and winter at Site 1 for each stocking rate treatment. The periods are equivalent to the corresponding periods in Fig. 4.5. The vertical arrow indicates the division between the animal summer and winter. (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

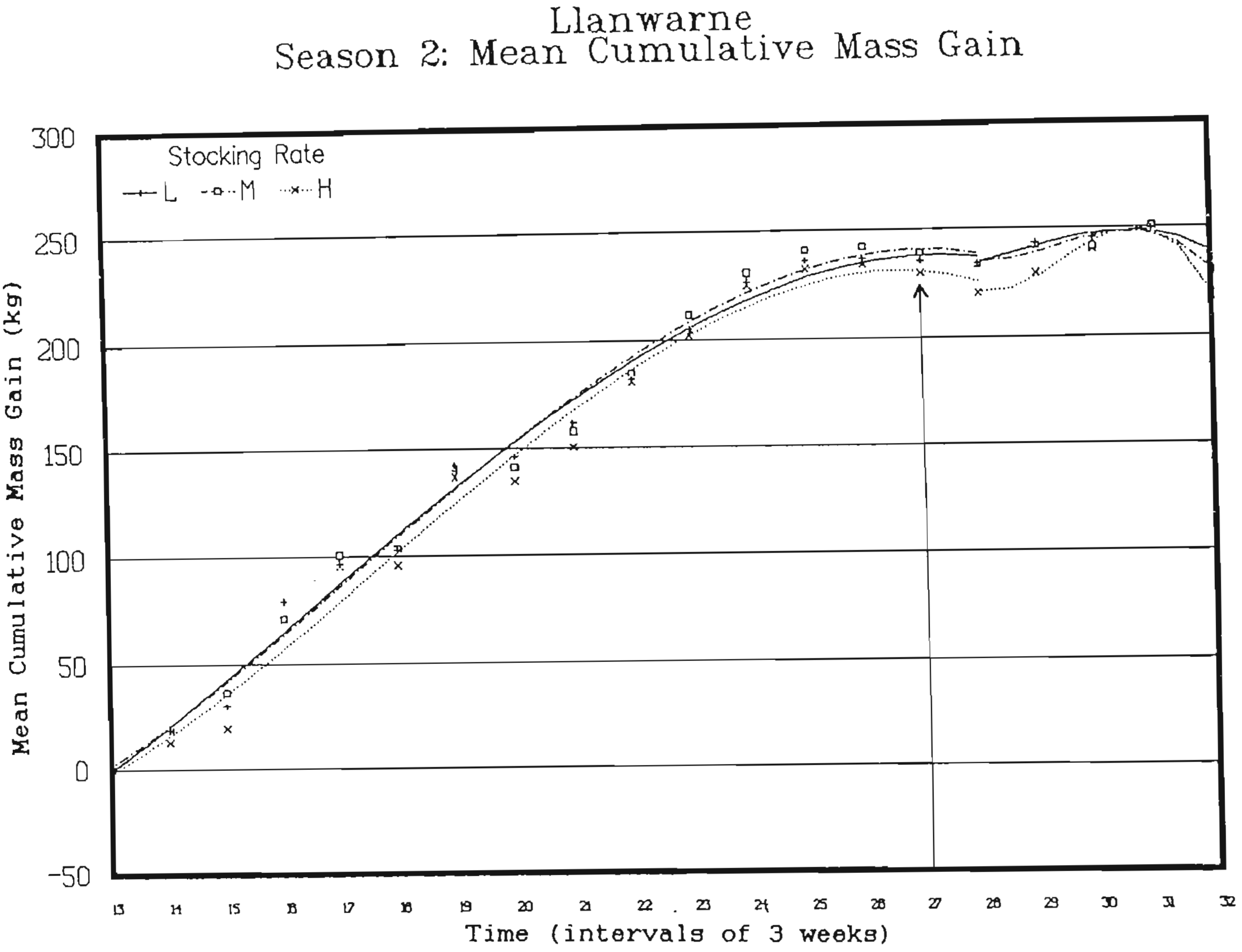


Fig. 4.7b. The <u>fitted mean cumulative mass gain (kg)</u> over <u>the second summer and winter at Site 1</u> for each stocking rate treatment. The periods are equivalent to the corresponding periods in Fig. 4.5. The vertical arrow indicates the division between the animal summer and winter. (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

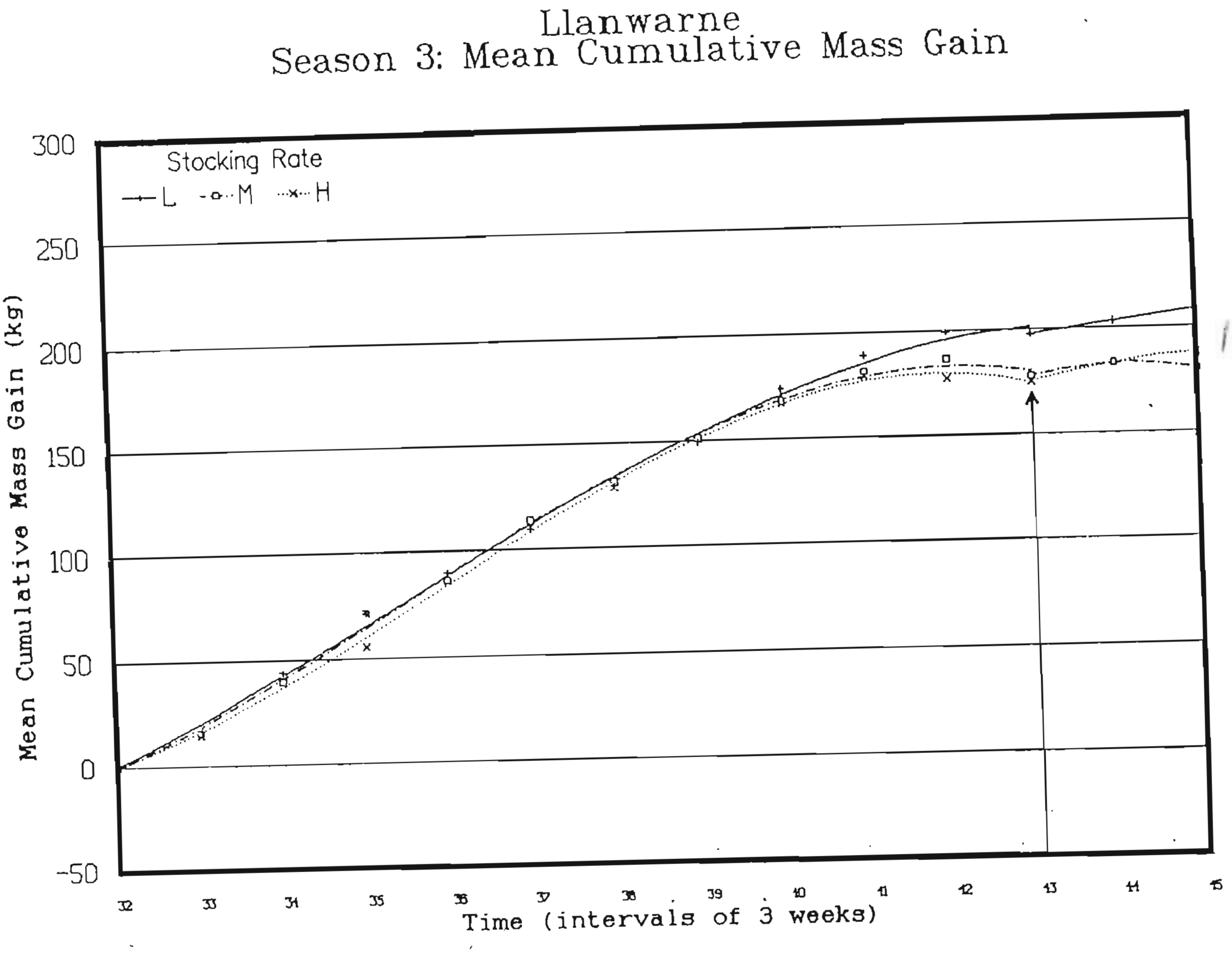


Fig. 4.7c. The fitted mean cumulative mass gain (kg) over the third summer and the start of the third winter at Site 1 for each stocking rate treatment. The periods are equivalent to the corresponding periods in Fig. 4.5. The vertical arrow indicates the division between the animal summer and winter. (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

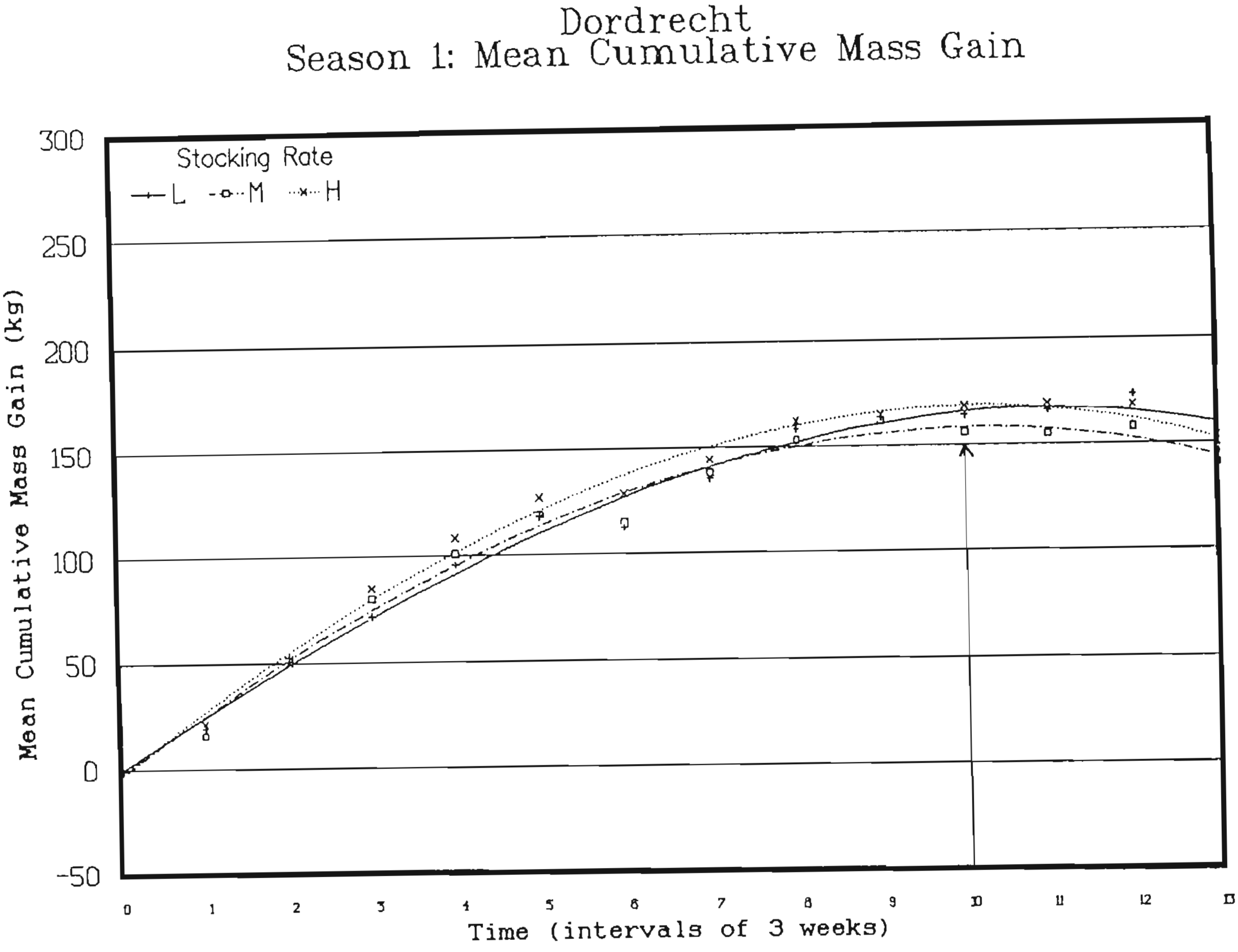


Fig. 4.8a. The <u>fitted mean cumulative mass gain (kg)</u> over <u>the first summer and winter at Site 2</u> for each stocking rate treatment. The periods are equivalent to the corresponding periods in Fig. 4.6. The vertical arrow indicates the division between the animal summer and winter. (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

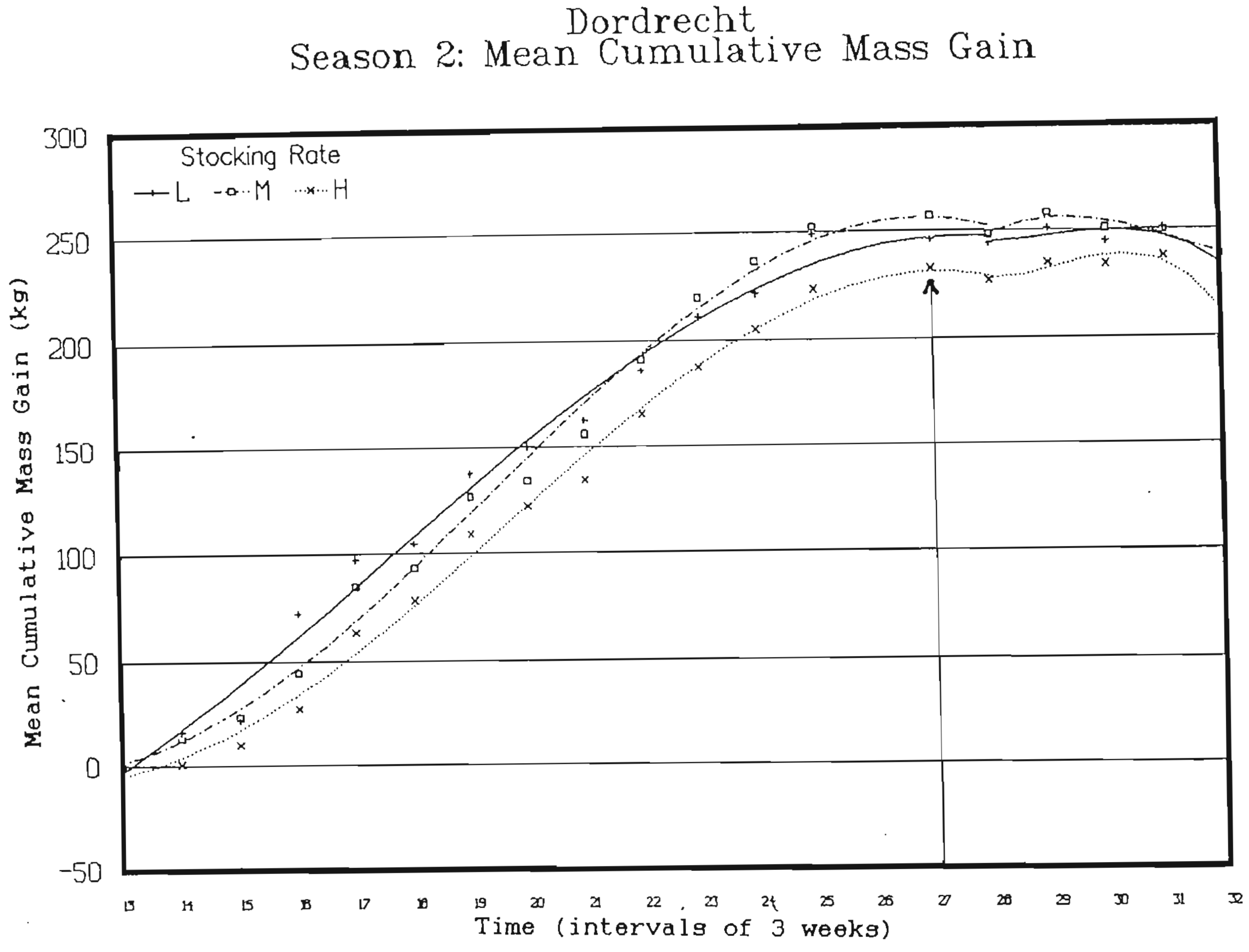


Fig. 4.8b. The fitted mean cumulative mass gain (kg) over the second summer and winter at Site 2 for each stocking rate treatment. The periods are equivalent to the corresponding periods in Fig. 4.6. The vertical arrow indicates the division between the animal summer and winter. (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

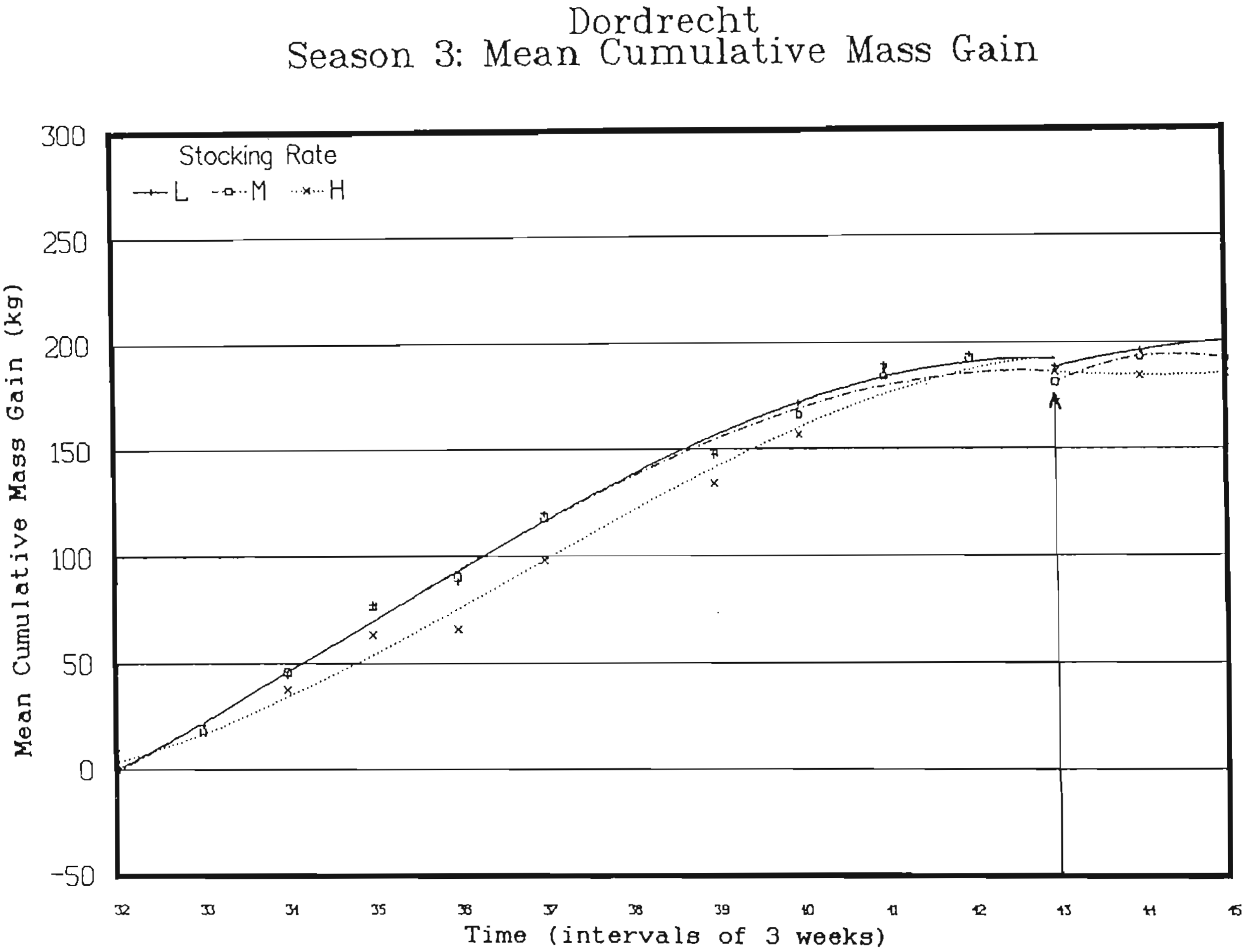


Fig. 4.8c. The fitted mean cumulative mass gain (kg) over the third summer and the start of the third winter at Site 2 for each stocking rate treatment. The periods are equivalent to the corresponding periods in Fig. 4.6. The vertical arrow indicates the division between the animal summer and winter. (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

Table 4.3. A summary of mean individual animal performance and stocking rate for Sites 1 and 2 derived from the fitted data. (The periods coincide with those in Figs 4.7 and 4.8 for the respective sites.) (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

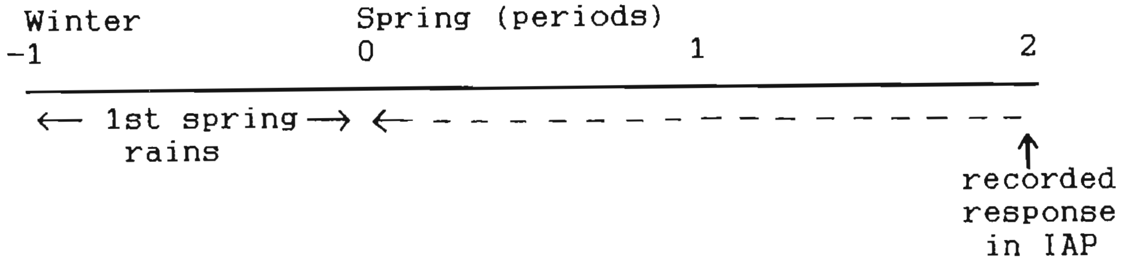
Site, & Periods	Length of period of gains/ losses (weeks)	Gains/losses (kg)			Actual Stocking Rate (LSU/ha)		
		L	M	H	L	M	H
Site 1							
0 - 10	30	175	169	152	0,17	0,28	0,31
10 - 13	9	-10	-11	-12	0,12	0,18	0,21
0 - 13	39	165	158	140	0,16	0,25	0,29
13 - 27	42	238	241	231	0,17	0,27	0,34
27 - 32	15	1	-11	- 7	0,14	0,20	0,28
13 - 32	57	239	230	224	0,16	0,25	0,33
32 - 43	33	202	180	174	0,18	0,25	0,32
0 - 43	129	606	568	538	0,17	0,25	0,31
Site 2							
0 - 10	30	166	158	169	0,17	0,21	0,31
10 - 13	9	- 6	-14	-17	0,12	0,14	0,20
0 - 13	39	160	144	152	0,16	0,20	0,28
13 - 27	42	247	257	231	0,19	0,25	0,30
27 - 32	15	-14	-18	-20	0,14	0,18	0,22
13 - 32	57	233	239	212	0,17	0,23	0,28
32 - 43	33	192	186	193	0,18	0,22	0,29
0 - 43	129	585	569	557	0,17	0,22	0,28

a. The strong and consistent effect of stocking rate on IAP which was anticipated for all seasons did not materialise, although in some seasons the effects of stocking rate were strongly evident (Table 4.3). Stocking rate appeared to have a more consistent effect on IAP during periods of mass loss than during periods of mass gain. However, if the total mean CMG over the first 43 3-week periods under evaluation are considered (which include summer and winter gains) (Figs 4.5 and 4.6 and Table 4.3), it was highest for the light stocking rate treatments and lowest for the heavy treatments at each site. Viewed in this way, therefore, the expected effect of stocking rate did materialise according to expectation.

b. The length of time over which animals gained mass i.e. the length of the animal summers, varied between seasons but remained consistent between stocking rate treatments at the same site and between sites in the same season (Figs 4.7 and 4.8 and Table 4.3).

The large variation in IAP between seasons deserves more careful consideration. The stocking rates for the different stocking rate treatments over the animal summers were not very different between seasons (Table 4.3). If one examines the lengths of the grass summers (shown in Figs 4.3 and 4.4) then it is immediately apparent that the rainfall in the second season fell over a much longer period than in the other two seasons (the distribution of the rainfall is clearly seen Figs 4.3 and 4.4). Although the cycles in animal mass gains did not coincide exactly with cycles in rainfall (and therefore in grass growth), if one carefully scrutinises the periods over which rain fell and relates these to animal mass gains, two important times can be identified for each of the 3 years. The first is in the spring when animal performance changed from mass loss to mass gain. The second is in the winter, when animal performance changed from mass gain to mass loss.

The change in animal performance from mass loss to mass gain in the spring was first measured two periods (6 weeks) after the first spring rains, illustrated as follows:



Several factors may have contributed to this apparent delay in response of animal gains to spring rainfall. The primary factor was probably the delay in grass growth after the rains had fallen. Sufficient green grass would probably only have been available to the animals about two to three weeks after the first spring rains because it takes time for grass to grow once rain has fallen. A secondary factor may be have been related to the time needed by rumen microflora to adjust to the change in diet from a relatively poor quality one (on seasons (the distribution of the rainfall is clearly seen Figs 4.3 and 4.4). Although the cycles in animal mass gains did not coincide exactly with cycles in rainfall (and therefore in grass growth), if one carefully scrutinises the periods over which rain fell and relates these to animal mass gains, two important times can be identified for each of the 3 years. The first is in the spring when animal performance changed from mass loss to mass gain. The second is in the winter, when animal performance changed from mass gain to mass loss.

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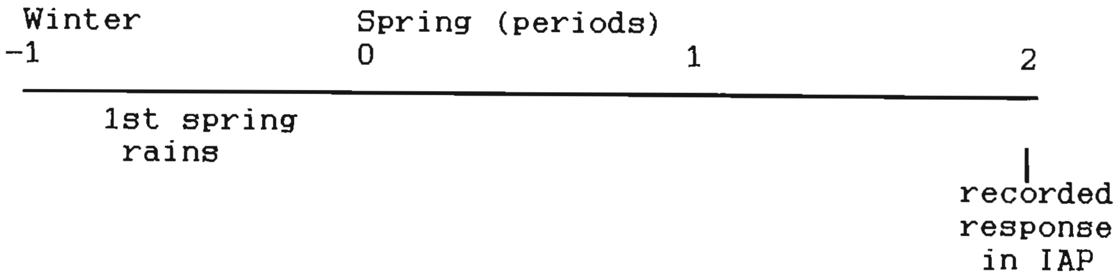
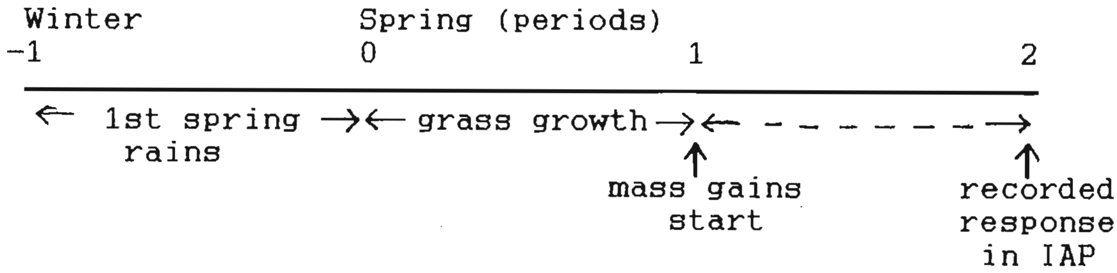
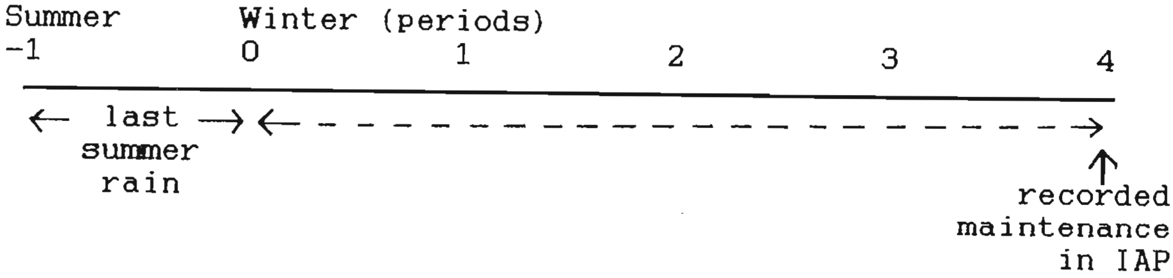


Several factors may have contributed to this apparent delay in response of animal gains to spring rainfall. The primary factor was probably the delay in grass growth after the rains had fallen. Sufficient green grass would probably have been available to the animals only about two to three weeks after the first spring rains because it takes time for grass to grow once rain has fallen. A secondary factor may be have been related to the time needed by rumen microflora to adjust to the change in diet from a relatively poor quality one (on which animals were not able to maintain) to a relatively high quality one (on which animals were able to gain in excess of 1 kg/day). The response may therefore be interpreted as follows:



The change in animal performance from mass gain to mass loss in the winter was not as clear. The transition, however, occurred about 4 periods (12 weeks) after the last summer rains. This is illustrated as follows:



The close link between animal gains and rainfall, in terms of the length of the season, is more clearly shown in Fig. 4.9. It should be noted that fitted daily gain (DG) data were used and that rainfall has been "moved" forward so that the rainfall now shown at a particular time period is that which occurred two periods previously (i.e. at T-2).

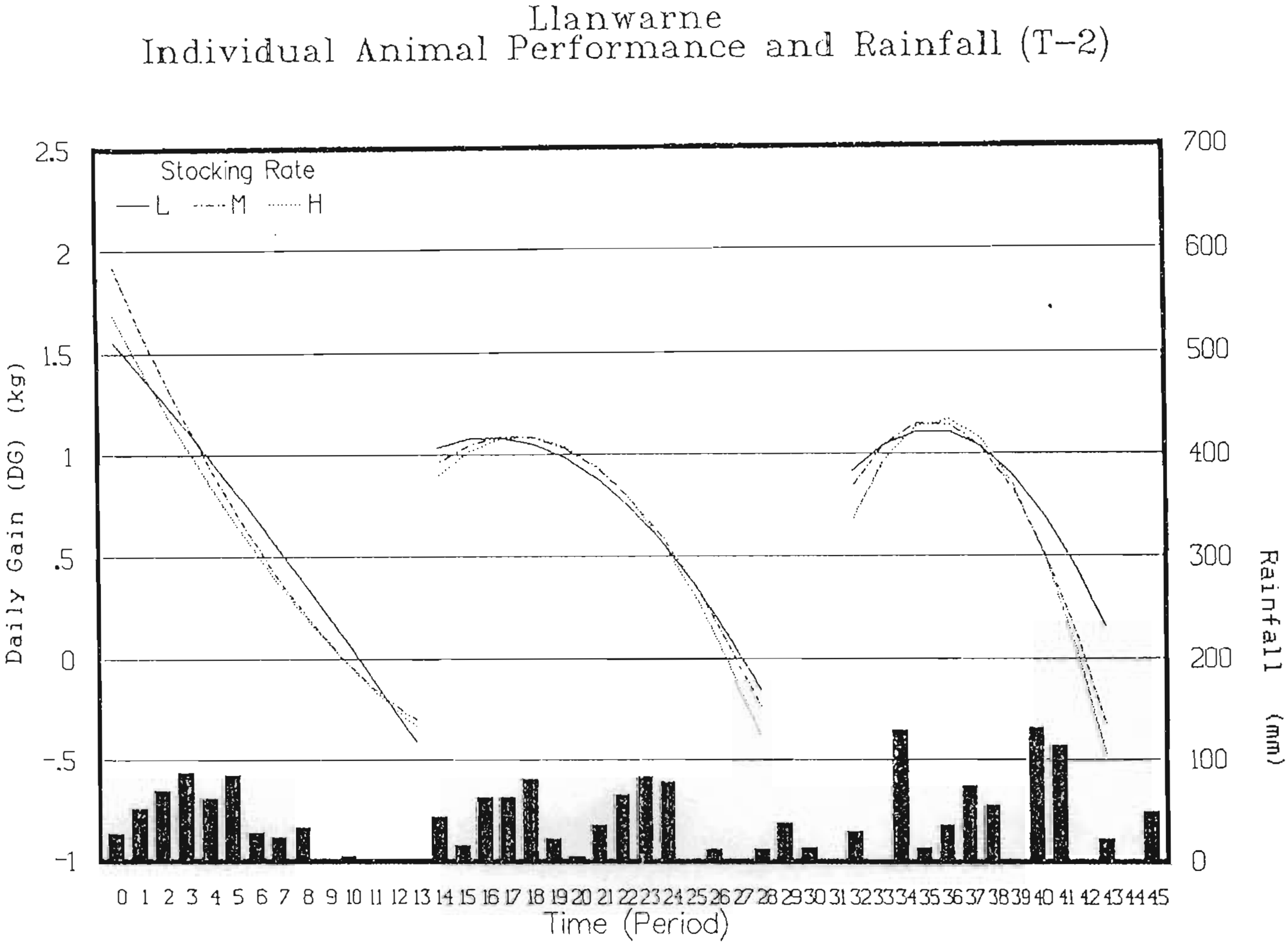


Fig. 4.9a. Individual animal performance (daily gain (kg/day)) in relation to rainfall (mm) for each stocking rate treatment at Site 1. The rainfall shown at any period is that which fell two periods prior to that period i.e. at the time minus 2 periods (T-2). (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

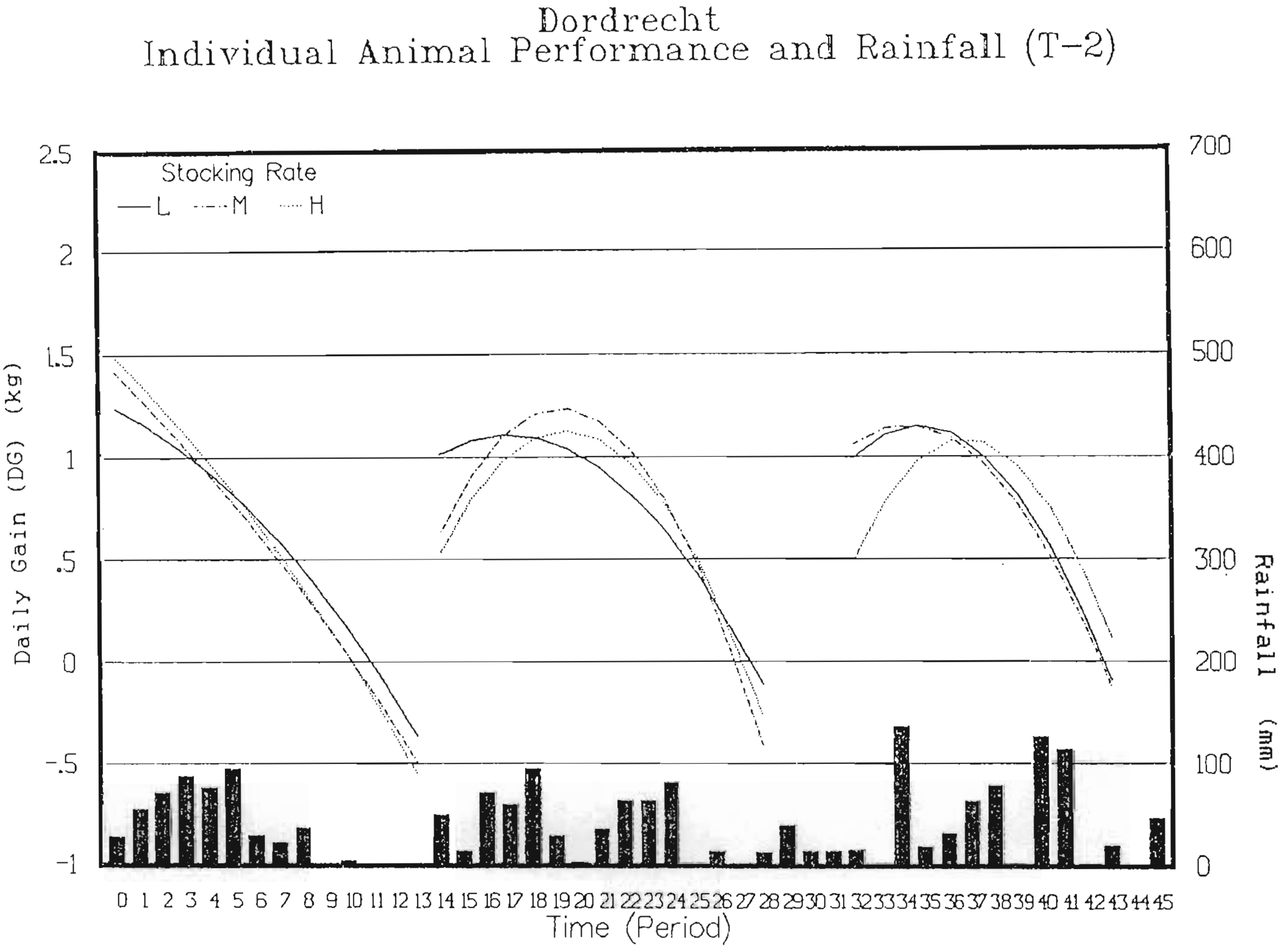


Fig. 4.9b. Individual animal performance (daily gain (kg/day)) in relation to rainfall (mm) for each stocking rate treatment at Site 2. The rainfall shown at any period is that which fell two periods prior to that period i.e. at the time minus 2 periods (T-2). (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

The link between the time over which rain falls over a season and animal mass gain and loss is probably through the effect that rainfall has on herbage production and therefore on the availability of green forage. In the Lowveld there is always a response in grass growth to rainfall, irrespective of the season in which that rain falls. If a particular amount of rain were to be distributed over a relatively long period, new and green grass would be available to animals for a much longer time than were the same amount of rain to fall over a relatively short period. Animals would therefore continue to gain mass over a much longer time and therefore gain much more in a "long" summer than in a "short" summer.

Note that in Fig. 4.9, IAP data have been omitted for part of the second winter (periods 29 to 31) and for the beginning of the third winter (periods 44 and 45). In both instances, the winter rains resulted in a flush of grass growth (referred to in Section 4.3 and seen in Figs 4.3 and 4.4). Once again there was a delay in animal response. However, in contrast to the summer situation, here response was of short duration. The reason for this is probably that the amount of new grass that was produced in response to the winter rain was insufficient to maintain an adequate supply of relatively high quality food for continued animal mass gain. Mass gains would therefore be expected to occur for a much shorter period after a single fall of rain in winter than following the last fall of rain in summer. It can be expected therefore that animals would continue gaining through the winter only provided rain fell at regular intervals.

CHAPTER 5

HERBAGE MASS COMPONENT MODELS FOR THE LOWVELD

CHAPTER 5

HERBAGE MASS COMPONENT MODELS FOR THE LOWVELD

5.1 A MODEL FOR PREDICTING HERBAGE MASS AT THE END OF THE GRASS SUMMER FOR THE LOWVELD

Total annual rainfall (July to June) increased over the three seasons (Table 4.1) but the peak HM that was attained at the end of the successive grass summers did not follow the same increasing trend (Figs 4.3 and 4.4). The direct inclusion of rainfall as a factor in a multiple linear regression model would therefore have shown rainfall to have had a negative effect on herbage production. As previous work has shown (Rutherford, 1978) such a result is contrary to expectation. Rainfall would, without doubt, have a significant positive effect on herbage production in this semi-arid environment. The problem in this case was overcome by developing a model which would predict HM per mm of rainfall which fell over the grass summer only.

Data from both sites were used to develop the model. The total data set therefore included data from 6 camps at each of 2 sites and for each of 3 seasons (or 36 sets of data). The parameters of the model are as follows.

a. Residual HM (kg/ha) at the end of the grass summers (identified in Section 4.3). This was calculated from DH recorded at that time using the general calibration curve for the DM for the Lowveld. This was divided by the summer rainfall (see b. below) to obtain a value of residual HM/mm rainfall at the end of the grass summer.

b. Rainfall (mm). This was the total which fell during the grass summer. Rain which fell in the grass winters was therefore excluded.

c. The effect of grazing during the grass summers. This was indexed by Large Stock Unit grazing days per hectare (LSU GDs/ha). This was calculated as follows:

$$\text{LSU GDs/ha} = \frac{\text{Days in} \times \text{number of animals} \times \text{LSUE}}{\text{Area of the camp}}$$

where

LSUE = Large Stock Unit Equivalence

The LSUE was calculated from fitted animal growth curves (see Section 4.4) over both the animal summer and winter periods i.e. a mean LSUE over the whole year. The effect of grazing was indexed in GDs because camps, even though they may have been assigned to the same stocking rate treatment, were not 1) grazed for equal time periods during a particular season and 2) all exactly the same size. Different stocking rates were therefore applied to each camp. The conversion to LSU GDs was essential to compensate for difference in animal size and performance and therefore also for differences in consumption of herbage.

d. Veld condition. This was indexed simply by the sum of the proportions of _Themeda_ _triandra_, _Panicum_ _maximum_ and _P_. _coloratum_ (Turner, 1988) i.e. the three species providing the bulk of the forage.

e. Residual HM (kg/ha) at the end of the preceding grass winter. This was calculated from the DH recorded at that time using the general calibration curve for the DM for the Lowveld. This was included because it was felt that it would be reasonable to assume that some of this residual herbage would contribute to the HM at the end of the following summer or at least that it may have been grazed so that more of the newly grown material would have survived grazing.

The model that was developed is as follows:

$$H_{sr} = 3,546 - 0,022259G_{s} + 0,033036V + 0,000789H_{w}$$

$$r^{2} = 0,53 \quad **$$

where

H_{sr} = Residual herbage mass (kg/ha/mm rainfall) at the end of the grass summer

G_{s} = Grazing days (LSU GDs/ha) for the grass summer

V = Veld condition index (sum of the proportions of Themeda triandra, Panicum maximum and P. coloratum)

H_{w} = Residual herbage mass (kg/ha) at the end of the preceding grass winter

Expressing the effects of stocking rate in terms of LSU GDs will have the spin-off that the model can be applied to predict HM for situations in which any class of cattle are stocked, provided they are expressed in terms of LSUE.

The index of veld condition that was used in the models was simply the sum of the proportion of Themeda triandra, Panicum maximum and P. coloratum. Other indices such as the proportion of Urochloa mossambicensis, Sporobolus smutsii and S. nitens did not improve the model. This is not surprising. The former index indicates the extent to which veld is in "good" condition while the latter indicates the extent to which veld is in "bad" condition. One would therefore expect the two indices to be inversely related.

5.2 A MODEL FOR PREDICTING HERBAGE MASS AT THE END OF THE GRASS WINTER FOR THE LOWVELD

Data from both sites were used to develop the model. The total data set therefore included data from 6 camps at each of 2 sites and for each of 2 seasons (or 24 sets of data). The parameters of the model are as follows.

a. Residual HM (kg/ha) at the end of the grass winter in question (identified in Section 4.3). This was calculated from DH recorded at that time using the general calibration curve for the DM for the Lowveld.

b. The effect of grazing (LSU GDs/ha) during the grass winter (the calculation of which is explained in Section 5.1).

c. Residual HM (kg/ha) at the end of the preceding grass summer. This was calculated from DH recorded at that time using the general calibration curve for the DM for the Lowveld.

The model that was developed is as follows:

$$H_W = 831 - 4{,}65G_W + 0{,}5066H_S$$

$r^2 = 0{,}55$ **

where

H_W = Residual herbage mass (kg/ha) at the end of the grass winter

G_W = Grazing days (LSU GDs/ha) for the grass winter

H_S = Residual herbage mass (kg/ha) at the end of the preceding grass summer

One would expect that the longer the period for which poorer quality forage was available to animals over the winter period i.e. the longer the grass winter, the more mass they would lose. It is important to note that in this model the length of the grass winter is not accounted for despite the comparatively long second grass winter (105 vs 189 days) that occurred. The reason for this is probably that the rainfall which occurred during the second grass winter resulted in sufficient winter grass growth to offset almost exactly the much longer period over which the second grass winter spanned. This model therefore should be regarded as preliminary and will require updating and refining as soon as additional data become available. Nonetheless, it will still be useful in modelling stocking rate should the user keep this in mind.

CHAPTER 6

ANIMAL PERFORMANCE COMPONENT MODELS FOR THE LOWVELD

CHAPTER 6

MODELS FOR ANIMAL PERFORMANCE FOR THE LOWVELD

6.1 A MODEL FOR PREDICTING SUMMER ANIMAL MASS GAINS FOR THE LOWVELD

The relationship between stocking rate and IAP was not linear, as one might have expected it to be. It was anticipated that other factors such as, for example, the length of the (summer) rainfall period, veld condition and HM (and therefore also summer rainfall), could have influenced animal performance.

Data from both sites were used to develop the model. The total data set therefore included data from 3 stocking rate treatments at each of 2 sites and for each of 3 seasons (or 18 sets of data). The parameters of the model are as follows.

a. Animal mass gains (kg/animal) over the animal summer (the lengths of which are shown in Figs 4.5 and 4.6).

b. Stocking rate (LSU/ha) for the animal summer. (Despite the possible practical disadvantages, it was felt that, with the large differences in the lengths of the animal summer that could occur between seasons, the use of stocking rate for the animal summer would be a better parameter than the stocking rate over the summer and winter combined.)

c. The length of the animal summer (weeks) (or the time over which gains occurred). This was simply the time from the 1st fall of rain at the beginning of the grass summer to the last fall of rain at the end of the grass summer, to which 9 weeks were added. The value of nine weeks was derived as follows: response in animal gain to rainfall started about 3 weeks only after the first rains of the grass summer (although the response was measured after 6 weeks) (see Section 4.4). Gains ceased 12 weeks after the last rains of the grass summer (see Section 4.4). Thus, to the length of the grass summer one has to subtract 3 weeks for the delay in animal gain response to the 1st rains and add 12 weeks for the continuation of gain after the last summer rain.

The model which was developed is as follows:

$$G = -4{,}3 - 77{,}1S_5 + 6{,}315T \qquad r^2 = 0{,}95 \quad **$$

where

G = Individual animal mass gain (kg/animal/season) for the animal summer

S_5 = Stocking rate (LSU/ha) for the animal summer

T = The length (weeks) of the animal summer (or the time over which animal mass gains occurred)

Both veld condition and HM proved to be non significant and resulted in improvements in r^2 in the order of only about 0,01. This is not surprising. First, little or no difference in quality would be expected between veld of different condition classes in sweetveld because all the species are very palatable, even those dominant in veld in poor condition. Second, although there were differences in available herbage during the three seasons there were probably only small differences in quality of forage at different levels of availability.

Significantly, stocking rate did not have a major impact on IAP in the Lowveld. The coefficient for stocking rate is 77,1 or a decrease of 77,1 kg/animal for each increment of 1 LSU/ha. The range in stocking rates which is applied in practice (even though these may result in overstocking) is about 3 to 10 ha/LSU or 0,33 to 0,1 LSU/ha. The difference in IAP over this range will be 17,7 kg/animal in favour of the light stocking rate. For the levels of IAP attained in these areas (see Table 4.3) this is certainly not regarded as a major effect. The reasons for the overriding effect of the length of the grass summer on IAP have already been discussed (see Section 4.4). However, it is important to note that the animals never experienced a severe food shortage during the animal summer i.e. their intake was probably never severely restricted.

Should food shortages occur in the summer, stocking rate would be expected to have a much greater effect on IAP than indicated in this model. From a farming point of view, should such a situation develop, there would be a large shortfall in the food required for the winter (equivalent of a severe drought), a totally undesirable situation. The effects of stocking rate on IAP in summer under these conditions are therefore not of great interest in modelling IAP for farming purposes.

6.2 A MODEL FOR PREDICTING WINTER ANIMAL MASS LOSSES IN THE LOWVELD

For the same reasons as those outlined in the model for predicting HM over the grass winter (Section 5.2), the model developed here must also be regarded as preliminary. Data from only two animal winters were available. The response of animals to grass production resulting from winter rain has been ignored because the periods over which responses were measured were short. They could therefore not reasonably be accounted for.

Data from both sites were used to develop the model. The total data set therefore included data from 3 stocking rate treatments at each of 2 sites and for each of 2 seasons (or 12 sets of data). The parameters of the model are as follows.

a. Animal mass loss (kg/animal) over the animal winter (Table 4.3).

b. Stocking rate (LSU/ha) for the animal winter.

c. Veld condition which was indexed simply by the sum of the proportions of _Themeda triandra_, _Panicum maximum_ and _P. coloratum_ (Turner, 1988).

d. Residual HM (kg/ha) for the end of the preceding grass summer. This was calculated from DH recorded at that time using the general calibration curve for the DM for the Lowveld.

The model that was developed for winter mass loss is as follows:

$$L = 33{,}8 + 21{,}4S_W - 0{,}45V - 0{,}0032H_S \qquad r^2 = 0{,}65 \;\; *$$

where

L = Individual animal mass loss (kg/animal/season) for the animal winter

S_W = Stocking rate (LSU/ha) for the animal winter

H_S = Residual herbage mass (kg/ha) at the end of the grass summer

V = Veld condition index (sum of the proportion of Themeda triandra, Panicum maximum and P. coloratum)

It is interesting to note that veld condition and HM were important factors which influenced IAP in the winters but not in the summers. The heavy stocking rate treatments, and at Site 2 the moderate stocking rate treatment as well, did not have abundant grass and therefore the animals probably suffered from restrictions on food intake.

It would be expected that the length of the winter would influence the total mass loss during the winter but this was not significant and therefore excluded from the model. A probable reason for this is that for a period during the second (and longest) winter, animals gained mass because of the flush of grass growth that resulted from rain in the second winter. Thus the expected greater mass loss during the second winter was probably offset by the period of gain during this winter.

CHAPTER 7

A STOCKING RATE MODEL FOR THE LOWVELD

CHAPTER 7

A STOCKING RATE MODEL FOR THE LOWVELD

7.1 A DESCRIPTION OF THE STOCKING RATE MODEL FOR THE LOWVELD

The component models described in Chapters 5 and 6 were integrated to produce a stocking rate model for the Lowveld, illustrated in Fig. 7.1. The following should be noted with respect to the layout in Fig. 7.1: some parameters (free standing) are essential for determining the direct inputs (in blocks with a single outline). The direct inputs are those required for obtaining output from the models (the positions of which are indicated by blocks which are shadowed). With the herbage mass models an additional step may be useful to determine the herbage available to the grazing animal (indicated by blocks with a double outline). The thin solid

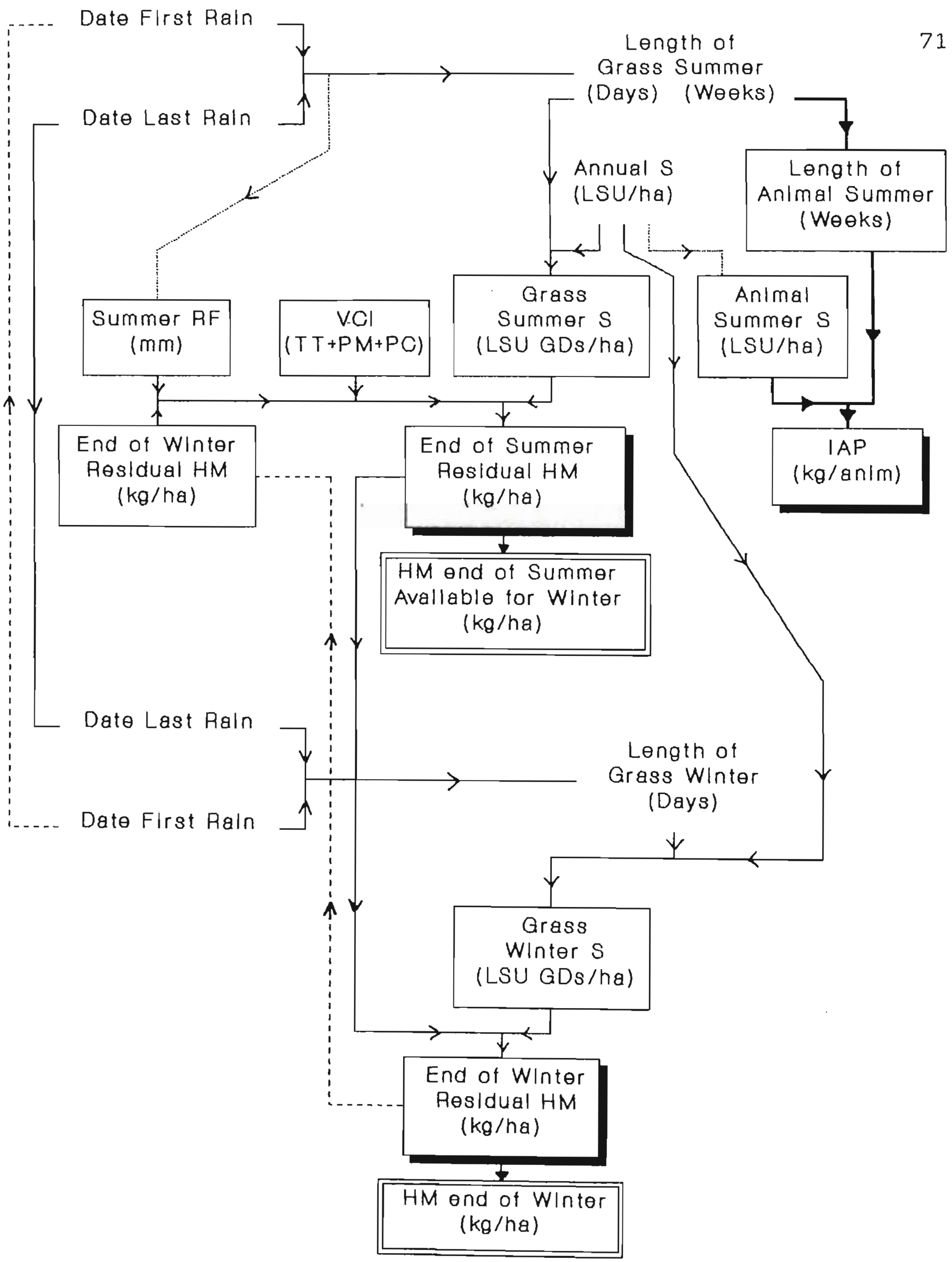


Fig. 7.1 A stocking rate model for the Lowveld. The layout is fully explained in the text.

lines indicate the flow of inputs to the herbage mass models. The thick solid lines indicate the flow of inputs to the animal performance model. The finely dotted lines indicate steps where the following parameter is indirectly calculated from the preceding parameter or requires some judgement. The stippled lines indicate the required flow of information for successive iterations of the model over successive seasons (with all other inputs remaining constant).

This model may be used for both planning purposes and for making management decisions at farm level. The applications and the suggested approaches for the use of the model in each of these applications is discussed in greater detail in the conclusion, because it applies equally to the models developed for the other two veld types.

7.2 PRACTICAL ASPECTS ON THE CALCULATION OF PARAMETERS

The calculation of the inputs has already been described in the development of the component models. However, in planning and management at farm level, all the parameters for running the model are not usually determined or recorded in such detail. In addition, farm operations also involve several classes of stock. Some guidelines for the calculation of the inputs at farm level may therefore prove useful.

a. Length of the grass summer. The date of the first summer rain (arbitrarily say > 15 mm, either in a single storm or dispersed over 2 or 3 days) should be fairly easy to establish in the Lowveld, particularly in seasons where the first seasonal rains are delayed. It would probably be reasonable to regard the 1st September as the start of the grass summers and therefore the first major rainfall event from this date onwards as the first summer rains. Although there may be a response in grass growth to rainfall throughout the winter, it is hoped that with data from several additional seasons, a model for winter grass growth could be developed and the winter animal performance model refined. The last summer rain cannot be determined in advance in the management application of the model. However, it is likely that this will occur before the end of March and almost certainly before the end of April. On this basis, in the application of the model in management, it could be run at the end of March taking the date of the last rainfall event prior to 31st March as the last day of the grass summer. In the application of the model for general planning, probabilities could be applied to the occurrence of rain up to a particular date, but it is suggested that 30th April be the latest date assumed for the end of the grass summer.

b. Summer rainfall (mm). This is the total rainfall that occurs between the dates of the first and last summer rain.

c. End of winter residual herbage mass (kg/ha). It must be borne in mind that this is the total above ground herbage mass and not the herbage available to the grazing animal. It is suggested that a grazing cut-off of 4 cm be adopted (although it is recognised that this may differ with different sward conditions and for different defoliation regimes). Because of the relatively heavy stocking rates that are currently being applied in these areas, it is unlikely that there will be much residual herbage in excess of that available to animals at the end of the winter. In the absence of estimates of residual herbage mass at the end of winter using the disc meter, the following guidelines are suggested:

heavily grazed sward - 4 cm or 1966 kg/ha;
moderately grazed sward - 5 cm or 2237 kg/ha; and
lightly grazed sward - 6 cm or 2508 kg/ha.

Should these be underestimates, it will introduce conservatism into the model. Note that the output from the model for the previous winter could also be used as input into the model for the following summer. However, such iteration of the model from season to season without some verification will be unwise in the application of the model. From experience, it is suggested that the end of the winter would be the easiest time to do such an evaluation in preference to the end of summer.

d. <u>Veld condition index (VCI)</u>. The important influence that veld condition has on grazing capacity will be clearly indicted later in this chapter. The need to collect reliable species composition data cannot be sufficiently stressed. The error in not having accurate species composition input may well be costly. Only three species contribute to the VCI in this veld type and this places objective veld condition assessment well within the capability of the farmer. However, realism has to be introduced. It will take time to collect such data. It will probably be better to use the model in the mean time (even if less store is placed on the outputs) than to wait for all the required data. Therefore, in the interim, it will probably suffice to have a "guestimate" by an expert. Certainly farmers should avoid subjectively assigning VCI's to their own farms themselves as they may fall to the temptation of overrating their veld. Here it is particularly important to stress that in any model

"garbage in = garbage out"!

e. <u>Grass summer stocking rate (S) (LSU GDs/ha)</u> for the end of summer HM component model. This is calculated from the mean annual stocking rate (Annual S (LSU/ha)). For the farm situation, LSUE should be realistically assigned to various classes of stock using the guidelines of Meissner, Hofmeyr, van Rensburg and Pienaar (1983).

f. <u>Animal summer stocking rate (S) (LSU/ha)</u> for the IAP component model. In the development of the models, summer stocking rate was calculated from animal mass data collected at regular intervals through the season. It is unrealistic to expect the same detail at farm level. From Table 4.3 it should be noted that the ratio of animal summer stocking rate to mean annual stocking rate is fairly consistent within years. The reasons for differences between seasons is that the relative contribution of summer stocking rate to the mean annual stocking rate varies according to the proportional lengths of the animal summer and winter in the respective seasons. In a short summer the relative contribution of summer stocking rate to mean annual stocking rate would be far less than in a long summer. It is therefore suggested that the ratios of summer:mean stocking rate derived from Table 4.3 be used to develop guidelines for deriving summer stocking rate from the mean annual stocking rate (Annual S (LSU/ha)). The following conversion factors derived from Table 4.3 for calculating summer stocking rate from mean annual stocking rate (which may require revision as more data become available), are suggested:

for a long animal summer (10 months) - 1.08;

for an intermediate animal summer (8,5 months) - 1,13; and

for a short animal summer (7 months) - 1,18.

The impact of stocking rate on animal performance over the range which would be applied in practice would be small. Some inaccuracy here will therefore not introduce a large error in the result. It should be noted that the length of the animal summer can be determined for any particular season at the time of the last summer rains because of the close link between the distribution of rainfall and animal performance.

g. Length of the animal summer (weeks). The close relationship between the grass and the animal summer in the Lowveld has been shown. The addition of 9 weeks to the length of the grass summer would therefore provide a good estimate of the length of the animal summer.

h. End of summer residual herbage mass (kg/ha). Once again it must be borne in mind that this is the total above ground herbage mass and not the available herbage. It is suggested that the output from the residual end of summer HM component model be used as the input for the end of winter residual HM component model, particularly where the end of summer residual HM cannot be objectively assessed.

i. <u>Grass winter stocking rate (S) (LSU GDs/ha)</u>. This is calculated in the same way as the summer stocking rate i.e. from the mean annual stocking rate (Annual S (LSU/ha)).

The calculation of the available residual herbage mass at the end of each season from the total residual herbage mass has been included in the model although the step is optional. The grazing cut-off suggested in Section 4.3 is 1966 kg/ha (a disc height of 4 cm). To obtain an estimate of available herbage, the estimated grazing cut-off is simply subtracted from the output of the herbage mass component models. The inclusion of this step therefore alleviates having to separate available and unavailable forage at a later stage and therefore simplifies the use of the herbage mass output.

7.3 MODELLING STOCKING RATE FOR THE LOWVELD

A typical scenario for the Lowveld is given in Table 7.1. This scenario forms the basis of the remaining discussion in this section in which the effects of altering the stocking rate and the length of the winter for veld in different conditions and for differences in rainfall will be assessed.

Table 7.1. A basic scenario using the stocking rate model for the Lowveld. A summer rainfall of 500 mm (used in the table) would approximate the mean summer rainfall for much of the Lowveld.

Mean annual S	(ha/LSU)	5.0
Mean annual S	(LSU/ha)	.20
SUMMER GRASS PRODUCTION:		
First summer rain	(date)	15 Oct
Last summer rain	(date)	31 Mar
Length grass summer	(days)	167
Length grass summer	(weeks)	24
Grass summer S	(LSU GDs/ha)	33
VCI	(TT+PM+PC)	50
HM (end of winter)	(kg/ha)	1966
HM (end of summer)	(kg/mm RF)	6.0
RF (summer)	(mm)	500
HM (end of summer)	(kg/ha)	2997
DH (grazing cut-off)	(cm)	4
HM (grazing cut-off)	(kg/ha)	1966
HM (available for winter use)	(kg/ha)	1031
WINTER GRASS PRODUCTION:		
Last summer rain	(date)	31 Mar
First summer rain	(date)	15 Oct
Length grass winter	(days)	198
Length grass winter	(weeks)	28
Grass winter S	(LSU GDs/ha)	40
HM (end of summer)	(kg/ha)	2997
HM (end of winter)	(kg/ha)	2165
HM (grazing cut-off)	(kg/ha)	1966
HM (available at the end of winter)	(kg/ha)	199

DH = Disc height
HM = Herbage mass
RF = Rainfall
S = Stocking rate
VCI = Veld condition index

Some points therefore need to be noted. The stocking rate of 0,2 LSU/ha (or 5 ha/LSU) is probably light in comparison with currently applied stocking rates in farming situations in this area. This has, however, been used as a basis for an intermediate stocking rate because it is the stocking rate which the author feels should be the absolute maximum for moderately good veld (VCI 70+) in this area. The dates of the first and last summer rains are probably a fair reflection of a "normal" year for the Lowveld (Schulze, 1982). No residual carry over of available herbage has been assumed. The HM values in the remaining tables will also be expressed as residual available herbage mass, assuming a grazing cut-off of 1966 kg/ha or a disc height of 4 cm.

The result of altering veld condition and rainfall in the model, under conditions otherwise similar to those in the scenario presented in Table 7.1, are shown in Table 7.2. Overwintering cattle without supplementary feeding would be possible on poor condition veld (VCI < 30) only in an above average rainfall year (average summer rainfall is about 500 mm). On veld in good condition (VCI > 70), cattle would only just overwinter in a very dry year (< 400 mm) without having to be supplemented. Of particular note is that for veld in poor condition and for a low rainfall (VCI < 30 and rainfall < 350 mm or VCI < 10 and rainfall < 400 mm), their would be a shortage of grass before the winter even began.

Table 7.2 Residual available herbage mass (HM) at the end of summer and the following winter for different levels of veld condition (VCI) and summer rainfall. All other conditions are the same as those in Table 7.1.

Summer Rainfall (mm)	End of Summer Residual HM (kg/ha)				
	VCI				
	10	30	50	70	90
350	0	0	136	367	598
400	0	172	436	701	965
450	142	439	737	1034	1331
500	376	706	1037	1367	1698
550	610	974	1337	1701	2064
600	845	1241	1637	2034	2430
650	1079	1508	1938	2367	2797
700	1313	1775	2238	2700	3163
	End of Winter Residual HM (kg/ha)				
350	0	0	0	0	0
400	0	0	0	32	166
450	0	0	50	201	351
500	0	35	202	369	537
550	0	170	354	538	722
600	105	306	506	707	908
650	223	441	658	876	1094
700	342	576	811	1045	1279

The decrease in ability to overwinter cattle when stocking rate is increased (from 5 ha/LSU or 0,2 LSU/ha to 3 ha/LSU or 0,33 LSU/ha), and the increase in ability when stocking rate is decreased (from 5 ha/LSU or 0,2 LSU/ha to 7 ha/LSU or 0,14 LSU/ha) under conditions otherwise similar to those shown in Table 7.2, is shown in Tables 7.3 and 7.4 respectively. In Table 7.3 it is shown that, at the heavier stocking rate, animals would require supplementation in dry years (<400 mm) even on the very best veld (VCI = 90) and that it would be impossible to achieve this stocking rate over a whole year on veld in poor condition (VCI < 10). In Table 7.4 it is shown that, at the lighter stocking rate, there would be little trouble overwintering cattle on veld in very good condition (VCI = 90) and that, even on veld in moderate condition (VCI = 50), cattle would only require supplementation in very dry years (< 400 mm).

Apart from rainfall per se, the time at which the first spring rain falls also has marked impact on livestock production. It is not unreasonable to suggest that, because the first rains are often delayed until late in the spring, provision should be made for sufficient veld to carry animals till at least the end of November without having to supply supplementary feed. The effect of a late spring rain, under condition otherwise similar to those in Table 7.1, but at the different stocking rates (the same as those in Tables 7.2, 7.3 and 7.4 i.e. 0,2, 0,33 and 0,14 LSU/ha), are shown in Tables 7.5, 7.6 and 7.7. The difference between the two extremes in

Table 7.3 Residual available herbage mass (HM) at the end of summer and the following winter for different levels of veld condition (VCI) and summer rainfall. All other conditions are the same as those in Table 7.2 except stocking rate which is heavier (0,33 LSU/ha or 3 ha/LSU).

Summer Rainfall (mm)	End of Summer Residual HM (kg/ha)				
	VCI				
	10	30	50	70	90
350	0	0	0	194	425
400	0	0	238	502	767
450	0	216	514	811	1108
500	128	459	789	1119	1450
550	338	701	1065	1428	1791
600	547	944	1340	1736	2133
650	757	1186	1616	2045	2474
700	966	1429	1891	2354	2816
	End of Winter Residual HM (kg/ha)				
350	0	0	0	0	0
400	0	0	0	0	0
450	0	0	0	0	115
500	0	0	0	121	289
550	0	0	93	277	462
600	0	32	233	434	635
650	0	155	373	590	808
700	43	278	512	746	981

Table 7.5 Residual available herbage mass (HM) at the end of summer and the following winter for different levels of veld condition (VCI) and summer rainfall. All other conditions are the same as those in Table 7.1 except the date of the first summer rain at the end of the winter which has been delayed to 30 November.

Summer Rainfall (mm)	End of Summer Residual HM (kg/ha)				
	VCI				
	10	30	50	70	90
350	0	0	136	367	598
400	0	172	436	701	965
450	142	439	737	1034	1331
500	376	706	1037	1367	1698
550	610	974	1337	1701	2064
600	845	1241	1637	2034	2430
650	1079	1508	1938	2367	2797
700	1313	1775	2238	2700	3163
	End of Winter Residual HM (kg/ha)				
350	0	0	0	0	0
400	0	0	0	0	123
450	0	0	7	158	308
500	0	0	159	327	494
550	0	127	311	496	680
600	62	263	464	664	865
650	181	398	616	833	1051
700	299	534	768	1002	1236

Table 7.6 Residual available herbage mass (HM) at the end of summer and the following winter for different levels of veld condition (VCI) and summer rainfall. All other conditions are the same as those in Table 7.5 except stocking rate which is heavier (0,33 LSU/ha or 3 ha/LSU).

Summer Rainfall (mm)	End of Summer Residual HM (kg/ha)				
	VCI				
	10	30	50	70	90
350	0	0	0	194	425
400	0	0	238	502	767
450	0	216	514	811	1108
500	128	459	789	1119	1450
550	338	701	1065	1428	1791
600	547	944	1340	1736	2133
650	757	1186	1616	2045	2474
700	966	1429	1891	2354	2816
	End of Winter Residual HM (kg/ha)				
350	0	0	0	0	0
400	0	0	0	0	0
450	0	0	0	0	44
500	0	0	0	50	217
550	0	0	22	206	390
600	0	0	162	362	563
650	0	84	301	519	736
700	0	206	441	675	909

Table 7.7 Residual available herbage mass (HM) at the end of summer and the following winter for different levels of veld condition (VCI) and summer rainfall. All other conditions are the same as those in Table 7.5 except stocking rate which is lighter (0,14 LSU/ha or 7 ha/LSU).

Summer Rainfall (mm)	End of Summer Residual HM (kg/ha)				
	VCI				
	10	30	50	70	90
350	0	0	210	442	673
400	0	257	521	786	1050
450	238	535	832	1129	1427
500	482	813	1143	1473	1804
550	727	1091	1454	1817	2181
600	972	1368	1765	2161	2558
650	1217	1646	2076	2505	2935
700	1462	1924	2387	2849	3312
	End of Winter Residual HM (kg/ha)				
350	0	0	0	0	40
400	0	0	0	97	231
450	0	0	120	271	422
500	0	111	278	445	613
550	67	251	435	620	804
600	191	392	593	794	995
650	315	533	750	968	1186
700	439	674	908	1142	1377

veld condition and for the two extremes in stocking rate is striking. On the one hand, on veld in poor condition and with heavy stocking (shown in Table 7.6), animals would have to be supplemented every time a late spring occurred, even if the late spring had been preceded by a very good summer (> 700 mm). On the other hand, on veld in good condition and with light stocking (shown in Table 7.7), animals would not need to be supplemented even after a late spring and even if the late spring had been preceded by a very dry summer (< 350 mm).

The animal performance component model has limited application in that it is applicable only to growing animals. An important constraint on the use of this component model is that it will be valid only when forage intake is not limiting to animal performance.

The animal performance component model is not influenced by grass production and veld condition, as is the situation in mixed and sourveld areas. A single table will therefore suffice to demonstrate the effects of stocking rate and the length of the grass summer on animal performance (Table 7.8). Stocking rate plays a relatively small role in influencing individual animal performance <u>during the summer</u>.

The winter animal mass loss component model was excluded from the overall stocking rate model because it was felt that it needed refinement. However, here it should be noted that while winter stocking rate does directly affect IAP, an

Table 7.8 Individual animal performance (kg/summer) in relation to the length of the grass summer, the length of the animal summer and stocking rate for the Lowveld.

Stocking Rate		Length of Grass Summer (weeks)				
(ha/LSU)	(LSU/ha)	16	21	26	31	36
		Length of Animal Summer (weeks)				
		25	30	35	40	45
10,0	0,10	146	177	209	241	272
6,7	0,15	142	174	205	237	268
5,0	0,20	138	170	201	233	264
4,0	0,25	134	166	197	229	261
3,3	0,30	130	162	194	225	257
2,9	0,35	127	158	190	221	253
2,5	0,40	123	154	186	217	249

increase in the total available forage in winter would result in substantially improved IAP. Thus, through its effect on forage availability in the winter, summer stocking rate indirectly affects IAP in the winter. In addition to the advantages of greater herbage production in summer from veld in good condition, the model indicates a further advantage to having veld in good condition. For the same availability of forage, animals will lose more mass on veld in poor condition than on veld in good condition, related probably to greater leaf drop associated with species occurring in veld in poor condition.

PART 3

THE DEVELOPMENT OF A STOCKING RATE MODEL FOR THE TALL GRASSVELD

CHAPTER

PART 3

OVERVIEW

In Natal, most of the Tall Grassveld lies in the Tugela River catchment in a band surrounding the central valleys in which the major rivers of this catchment meet and which form part of the Valley Bushveld (Acocks, 1975: Veld Type 23, variation a). Other outliers of Tall Grassveld occur further south and north. The Tall Grassveld is the main veld type of the Natal Midlands. It covers an area of approximately 11 551 km² (13,2%) of Natal (Edwards, 1974). The topography is one of rolling hills but with dolerite ridges and hills scattered throughout the area.

The mean annual rainfall varies from about 700 mm to 900 mm or more (Shulze, 1982). The seasonal variation in rainfall is also large. In very dry seasons, the drier parts may receive as little as 350 mm while in very wet seasons the more moist parts may receive as much as 1300 mm. The rain falls mainly in the summer months. However, winter falls of rain usually occur in July and August. Snow also falls occasionally but not every winter.

Frost occurs in winter so the winters are cold. This puts a restriction on grass growth during this period.

The Tall Grassveld is a fire climax grassland but it may take on the appearance of a very open savanna because of the occurrence of *Acacia sieberana* (an indicator species of this veld type), particularly on the dolerite outcrops. Distinct grass communities may often be identified, influenced to a large extent by soils and topography. For example the more moist southern aspects are often dominated by *Tristachya leucothrix*. Dolerite outcrops are generally dominated by a dense cover of *Themeda triandra*. Old lands, which are plentiful in this veld type, are typically dominated by *Hyparrhenia hirta*.

In veld considered to be in good condition, the grass sward is dominated by *Themeda triandra*. However, on south facing aspects, *Tristachya leucothrix* may also be abundant. Mild overgrazing will result in an increase in *Heteropogon contortus*. Degraded veld is typically dominated by such species as *Eragrostis racemosa*, *Rhynchelytrum repens*, *Microchloa caffra*, and *Aristida congesta* subsp. *barbicollis*.

Although Hyparrhenia hirta does sometimes occur in some abundance (5-15% of the proportional species composition), it always appears to be far more abundant than it actually is, giving the appearance of a "tall" grassveld. Perhaps the feature of this veld type which sets it aside from other mixed and sourvelds in Natal, is that the species which are abundant in degraded veld are usually moderately acceptable to livestock.

Mixed farming is typically practised in these areas. The main agricultural products are beef, mutton (with some income from wool), milk (usually produced in intensive systems), maize, wheat and some grain sorghum. Beef production is generally, however, the most important farming enterprise in these areas. It is the largest veld type in Natal in which beef is the primary agricultural product.

Cattle are run on the veld all year. Use is generally made of licks. During the summer animals are usually supplemented with mineral licks and during the winter with rumen stimulating licks. Hay is usually produced as a winter feed and as a fodder reserve from both veld and from cultivated pastures. In beef production systems, pastures, when available, are used primarily to finish animals for market. Veld none the less remains the basis for livestock production.

As for the Lowveld, here also the primary objectives for veld management should be 1) to ensure a good productive sward and 2) to ensure that there is sufficient grass to run animals on veld throughout the year without having to purchase supplementary feed.

Pastures are being increasingly established, particularly on land which is marginal for maize production. Summer pastures often encountered are *Cynodon* species (particularly Coastcross 2 and more recently Tifton 78), *Eragrostis curvula* (primarily for hay) and *Digitaria eriantha*. Winter pastures are also widely grown under irrigation, particularly *Lolium multiflorum* (ryegrass).

Fire is an important management tool in these areas although some farmers claim to have been able to manage their veld without burning for many years. However, it is often after a very wet year that veld which has not been burnt for many years becomes moribund and "collapses". Veld should be burnt at a time when it is dormant. Regulations are that in the more moist areas (> 800 mm mean annual rainfall) burning may not take place before the first spring rains (>15 mm) and not before 1 August or after 15 October, and in the drier areas (< 800 mm mean annual rainfall) burning may not take place without having had spring rains and not before 15 August or after 31 October. The time that the veld is burnt within the dormant winter period does not, however, appear to make any difference to recovery after a burn. It is the post-burn grazing management that appears to be the critical factor in a burning programme.

CHAPTER 8

RESULTS AND DISCUSSION

CHAPTER 8

RESULTS AND DISCUSSION

8.1 RAINFALL

Monthly rainfall for Sites 3, 4 and 5 is shown in Figs 8.1, 8.2 and 8.3 respectively. Also indicated is the expected distribution of rainfall (Shulze, 1982) for the amount received in each particular season. The annual rainfall over the three years for the three sites situated in the Tall Grassveld is shown in Table 8.1.

At Site 3, rainfall was slightly above average for the first season, above average but not exceptionally so in the second season and slightly below average in the third season. At Sites 4 and 5, however, rainfall was well above average for

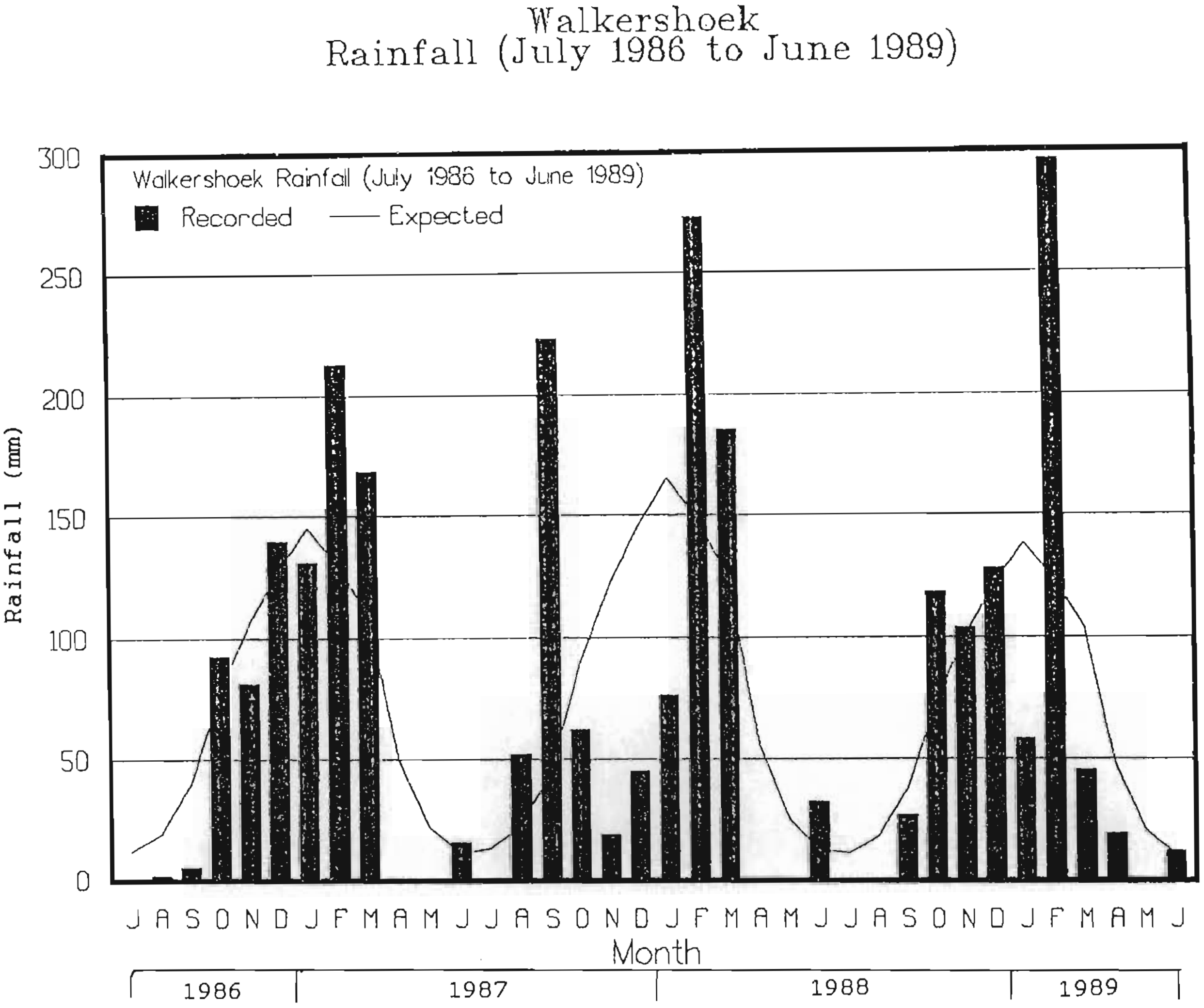


Fig. 8.1. Monthly rainfall at Site 3 over the three year experimental period. The solid line indicates the expected distribution of rainfall over the three years, based on mean long-term percentage distribution for each month.

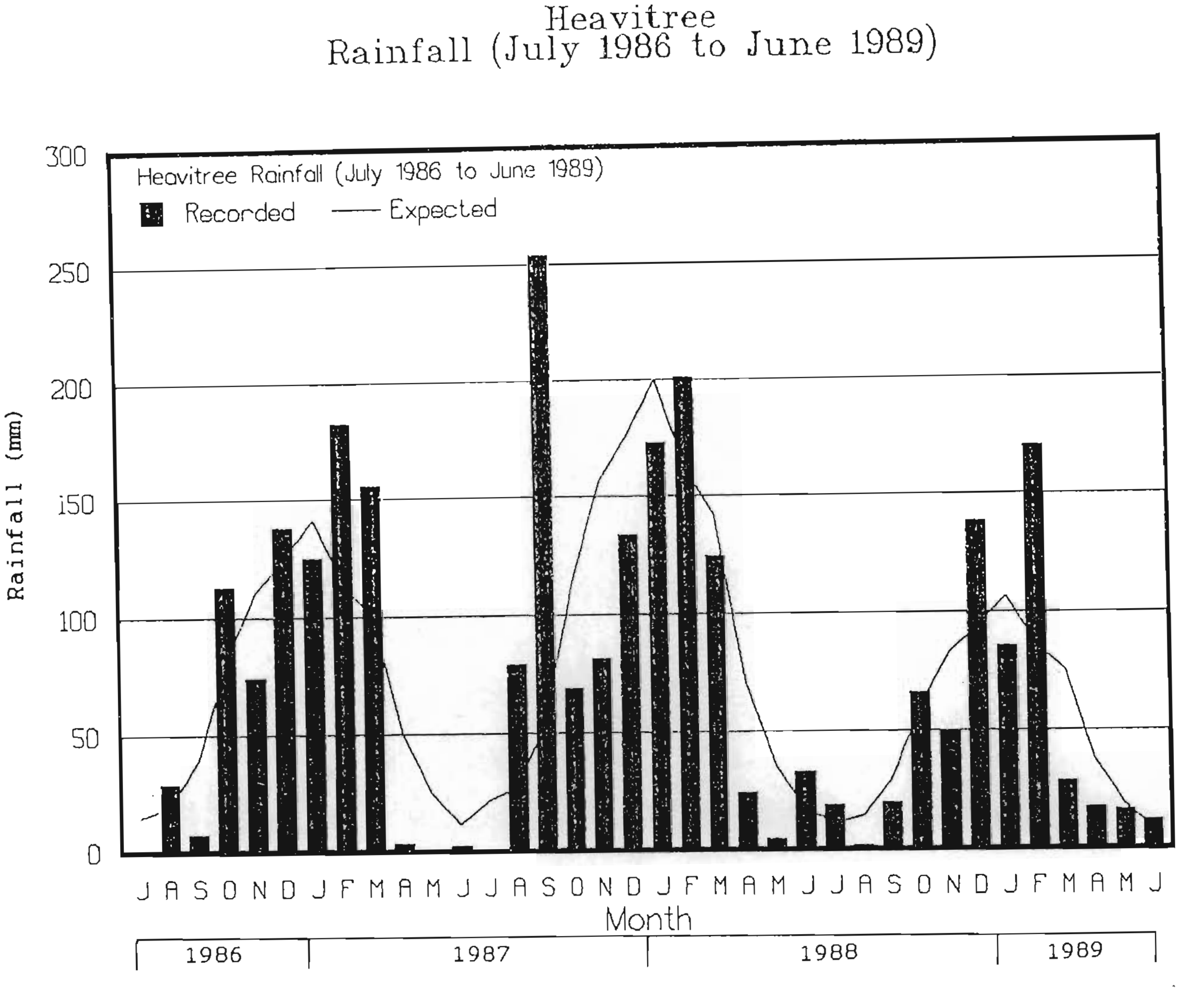


Fig. 8.2. Monthly rainfall at Site 4 over the three year experimental period. The solid line indicates the expected distribution of rainfall over the three years, based on mean long-term percentage distribution for each month.

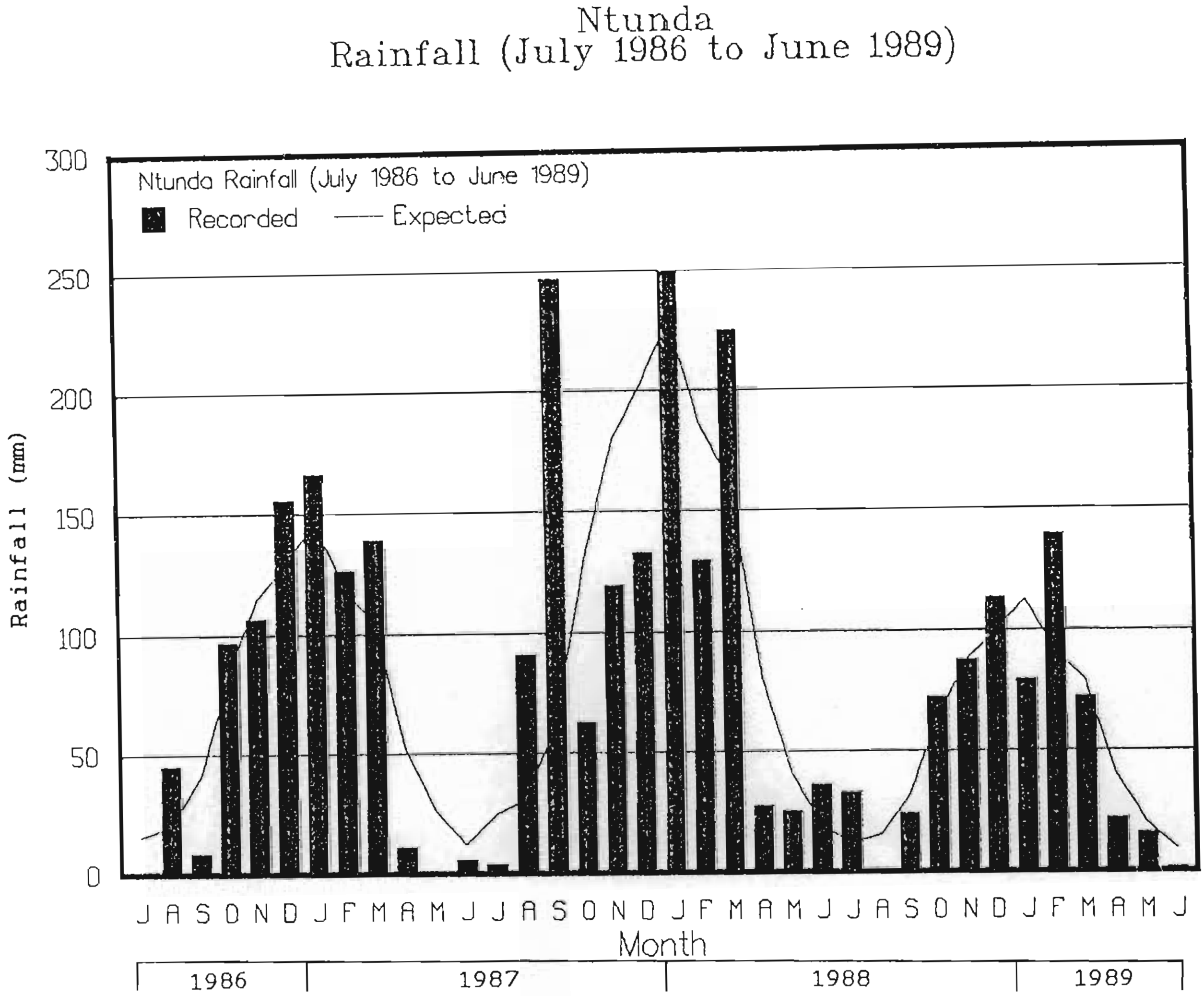


Fig. 8.3. <u>Monthly rainfall at Site 5</u> over the three year experimental period. The solid line indicates the expected distribution of rainfall over the three years, based on mean long-term percentage distribution for each month.

Table 8.1. Seasonal and average rainfall over the three year trial period and mean long-term rainfall for Sites 3, 4 and 5.

Season	Rainfall (mm)		
	Site 3	Site 4	Site 5
1986/87	850	831	864
1987/88	970	1176	1351
1988/89	811	626	664
mean	877	878	960
mean long-term	830	725	720

the first season, exceptionally high in the second season and below average in the third season.

8.2 VELD CONDITION

Proportional species composition data collected in January 1987 were used to develop indices of veld condition. It was assumed that there was no change in veld condition over the three seasons under analysis. As indicated for the Lowveld, this may not be entirely correct. However, with the relatively favourable first two seasons, major adverse changes are unlikely. Neither the heavy nor the light stocking rates which were applied are considered to have been exceptionally heavy or light.

Assessment of these data indicated that only eight grass species occurred with an abundance of over 5% in any particular camp (Table 8.2). These species are *Themeda triandra*, *Tristachya leucothrix*, *Hyparrhenia hirta*, *Heteropogon contortus*, *Eragrostis racemosa*, *Digitaria eriantha*, *Microchloa caffra* and *Sporobolus pectinatus*. At Site 3 they made up 73%, at Site 4 79% and at Site 5 70% of the total proportional species composition. Individually, therefore, other species would have contributed relatively little to herbage production.

Table 8.2. The proportional species composition of the eight grass species which made up at least 5% of the proportional species composition in any single camp at Sites 3, 4 and 5. (L, M and H are the light, moderate and heavy stocking rate treatments respectively and m = mean.)

Site, Treatment & camp	Proportional species composition (%)							
	TTR	TLE	HCO	HHI	ERA	DMO	MCA	SPE
L1	68	3	1	5	3	0	0	0
L2	55	7	6	10	3	0	0	0
L3	28	20	7	5	2	0	0	0
L4	33	24	6	2	7	0	1	0
mL	46	13	5	6	4	0	0	0
M1	24	0	3	5	13	0	0	0
M2	51	15	8	5	3	0	0	0
M3	35	17	8	7	10	0	0	0
M4	38	20	10	4	9	0	0	0
mM	37	13	7	5	9	0	0	0
H1	46	6	3	8	2	0	0	0
H2	41	16	4	6	4	0	0	0
H3	37	26	8	6	5	0	0	0
H4	48	18	9	6	3	0	0	0
mH	43	16	6	7	3	0	0	0
m(Site 3)	42	14	6	6	5	0	0	0
L1	29	38	5	4	4	1	3	0
L2	22	36	6	6	4	3	4	0
L3	31	26	1	5	5	6	2	0
L4	44	1	7	7	7	4	3	0
mL	32	25	5	6	5	4	3	0
M1	20	55	5	4	4	1	0	0
M2	23	31	6	5	4	3	4	1
M3	26	24	6	4	9	6	1	0
M4	41	10	7	3	6	8	2	0
mM	28	30	6	4	6	4	2	0
H1	30	27	5	6	7	4	4	0
H2	25	36	3	8	5	2	1	0
H3	25	30	4	4	6	6	2	0
H4	28	25	4	4	5	5	2	0
mH	27	29	4	6	6	4	2	0
m(Site 4)	29	28	5	5	6	4	2	0

Table 8.2. Continued.

Site, Treatment & camp	Proportional species composition (%)							
	TTR	TLE	HCO	HHI	ERA	DMO	MCA	SPE
L1	18	1	11	14	7	5	5	3
L2	19	4	12	3	6	8	8	10
L3	27	8	11	13	5	4	4	2
L4	20	3	10	6	4	7	9	6
mL	21	4	11	9	6	6	7	5
M1	16	4	10	6	10	7	13	6
M2	21	1	11	3	6	5	11	9
M3	25	5	12	7	6	5	5	4
M4	21	1	15	3	4	7	15	2
mM	21	3	12	5	7	6	11	5
H1	20	4	16	8	7	3	11	4
H2	16	4	14	6	7	9	11	4
H3	22	3	9	5	5	6	12	5
H4	15	3	15	2	5	12	11	8
mH	18	4	14	5	6	8	11	5
m(Site 5)	20	4	12	6	6	7	10	5

TTR = *Themeda triandra*
TLE = *Tristachya leucothrix*
HCO = *Heteropogon contortus*
HHI = *Hyparrhenia hirta*
ERA = *Eragrostis racemosa*
DMO = *Digitaria monodactyla*
MCA = *Microchloa caffra*
SPE = *Sporobolus pectinatus*

8.3 CHANGES IN DISC HEIGHT AND HERBAGE MASS

The changes in DH for each camp are presented in Figs 8.4, 8.5 and 8.6 for Sites 3, 4 and 5 respectively. Data were collected every three weeks. The first data (period 0) were collected on 20 November 1986 for Site 4 and one day either side for Sites 3 and 5 respectively, and the last data for Sites 3 and 4 (period 45) on the 21 June 1989 and for Site 5 (period 44) on 1 June 1989. Also indicated in these figures are 1) the rainfall which occurred during every period and 2) whether or not camps were grazed during the period. DM readings relate to each measuring time (which were 3 weeks apart) but rainfall and grazing relate to the interval between measuring times prior to the time indicated. It should also be noted that the figures are not arranged in the order that groups of camps at a particular site are numbered. For convenience of comparison, they are arranged so that groups of camps which received comparable treatments at the different sites in a particular season are in the same order. Therefore the sub-figure (a) in Figs 8.4, 8.5 and 8.6 represent the groups of camps at each site which were rested during the first summer, grazed first in the rotation in the second summer and grazed second in the rotation in the third summer and so on.

The large decreases which are shown to have suddenly occurred (for example for periods 14 and 31 at Site 3 and for the lightly stocked camp of group 1 (Fig. 8.4d)), were the

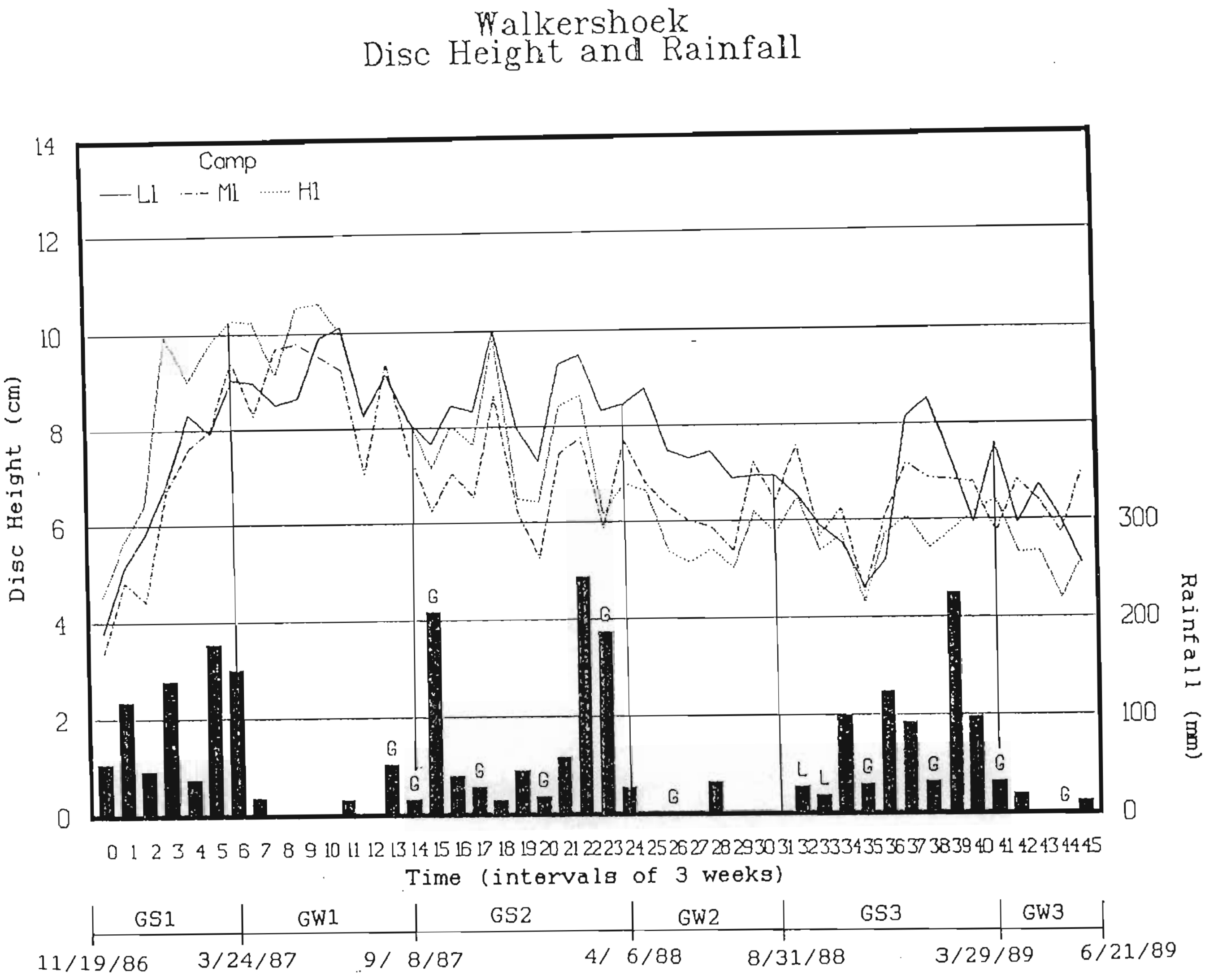


Fig. 8.4a. <u>Disc height (cm)</u> at each measuring period for each camp of <u>group 1 at Site 3</u>. Also indicated is the rainfall (mm) that occurred during each period and the periods during which each camp in the group was grazed (G = whole group; where the whole group was not grazed the camps from the respective treatments are indicated). The vertical lines show the grass summers (GS) and grass winters (GW) (which are labelled below the X-axis). (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

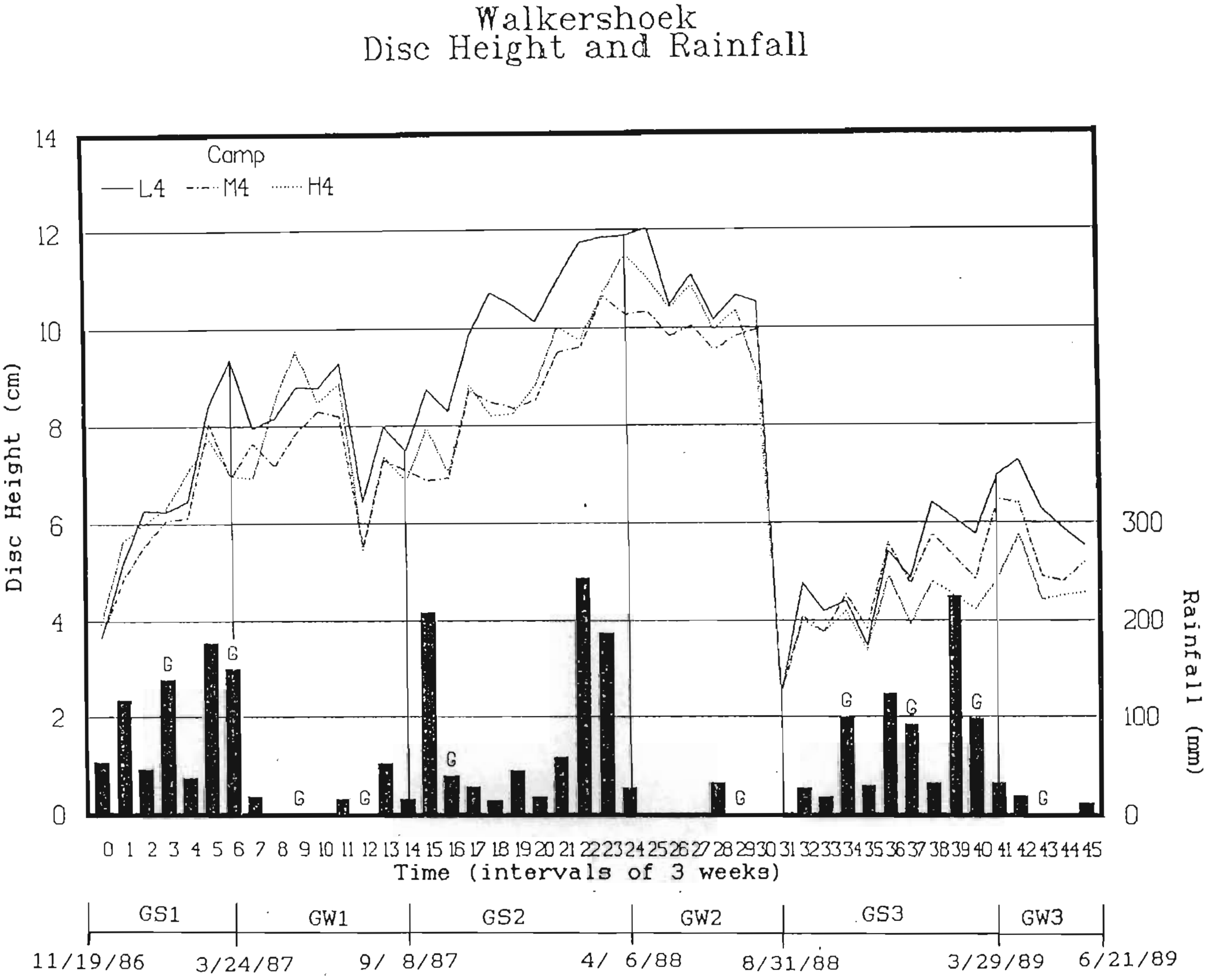


Fig. 8.4b. Disc height (cm) at each measuring period for each camp of group 4 at Site 3. Also indicated is the rainfall (mm) that occurred during each period and the periods during which each camp in the group was grazed (G). The vertical lines show the grass summers (GS) and grass winters (GW) (which are labelled below the X-axis). (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

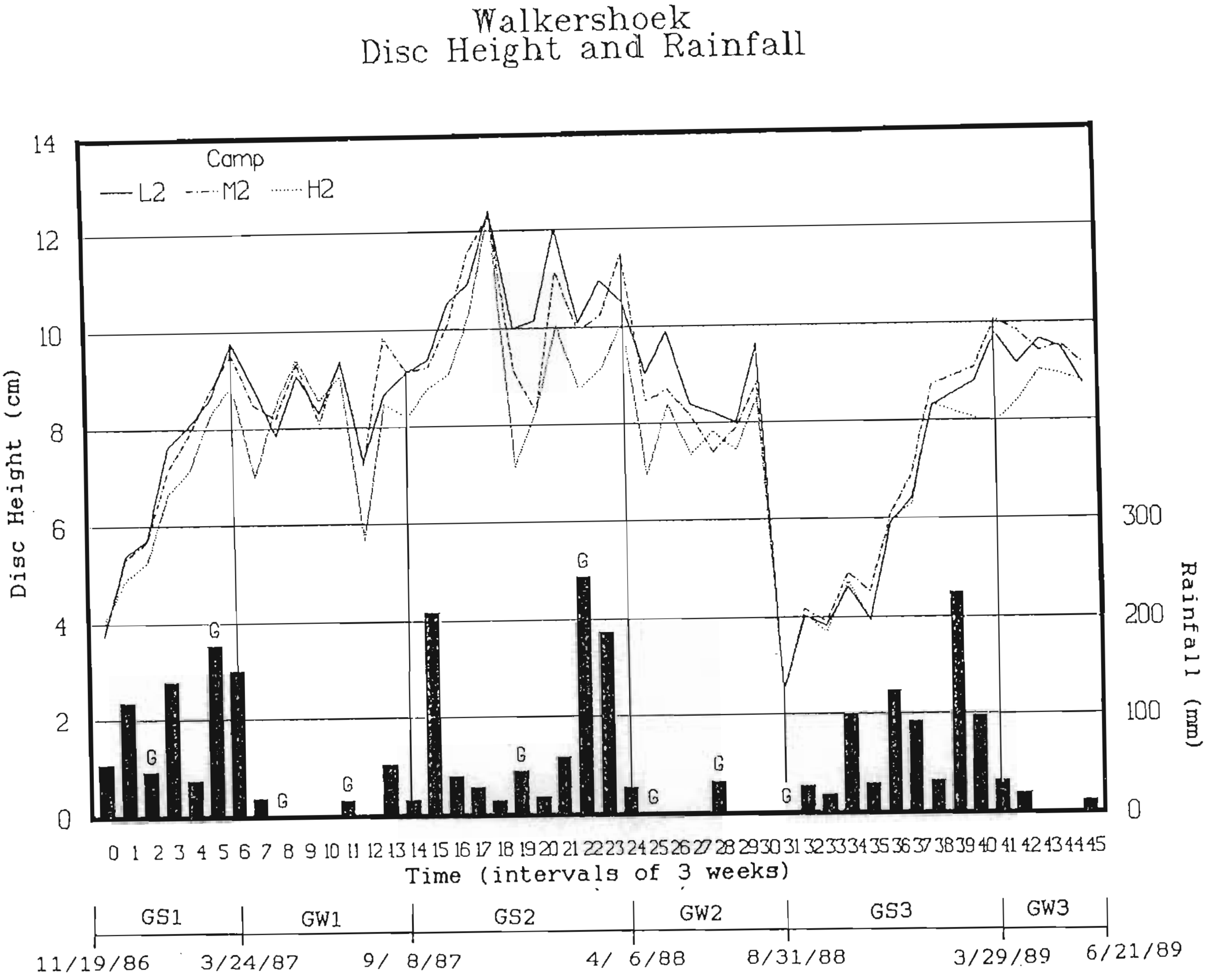


Fig. 8.4c. Disc height (cm) at each measuring period for each camp of group 2 at Site 3. Also indicated is the rainfall (mm) that occurred during each period and the periods during which each camp in the group was grazed (G). The vertical lines show the grass summers (GS) and grass winters (GW) (which are labelled below the X-axis). (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

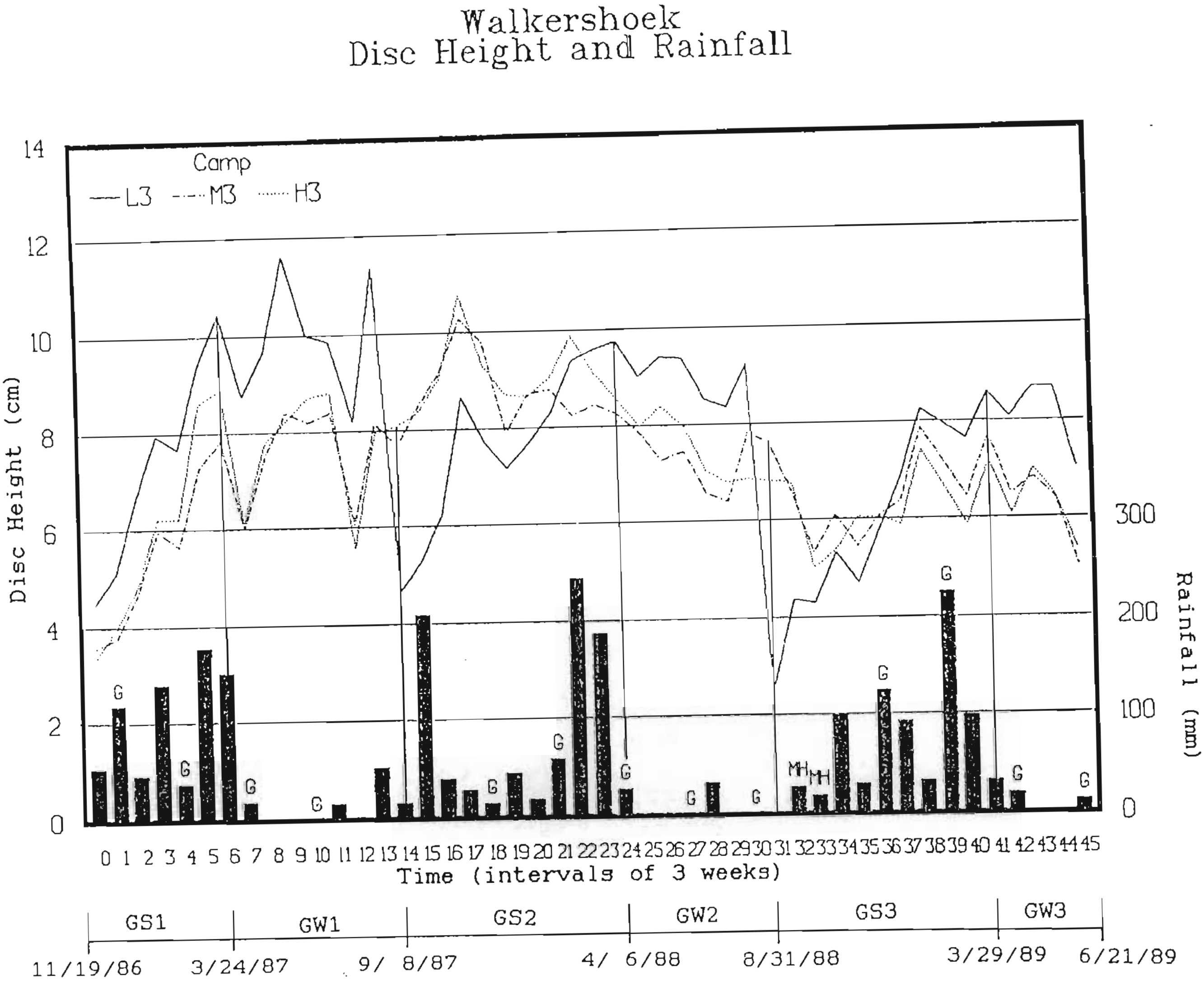


Fig. 8.4d. Disc height (cm) at each measuring period for each camp of group 3 at Site 3. Also indicated is the rainfall (mm) that occurred during each period and the periods during which each camp in the group was grazed (G = whole group; where the whole group was not grazed the camps from the respective treatments are indicated). The vertical lines show the grass summers (GS) and grass winters (GW) (which are labelled below the X-axis). (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

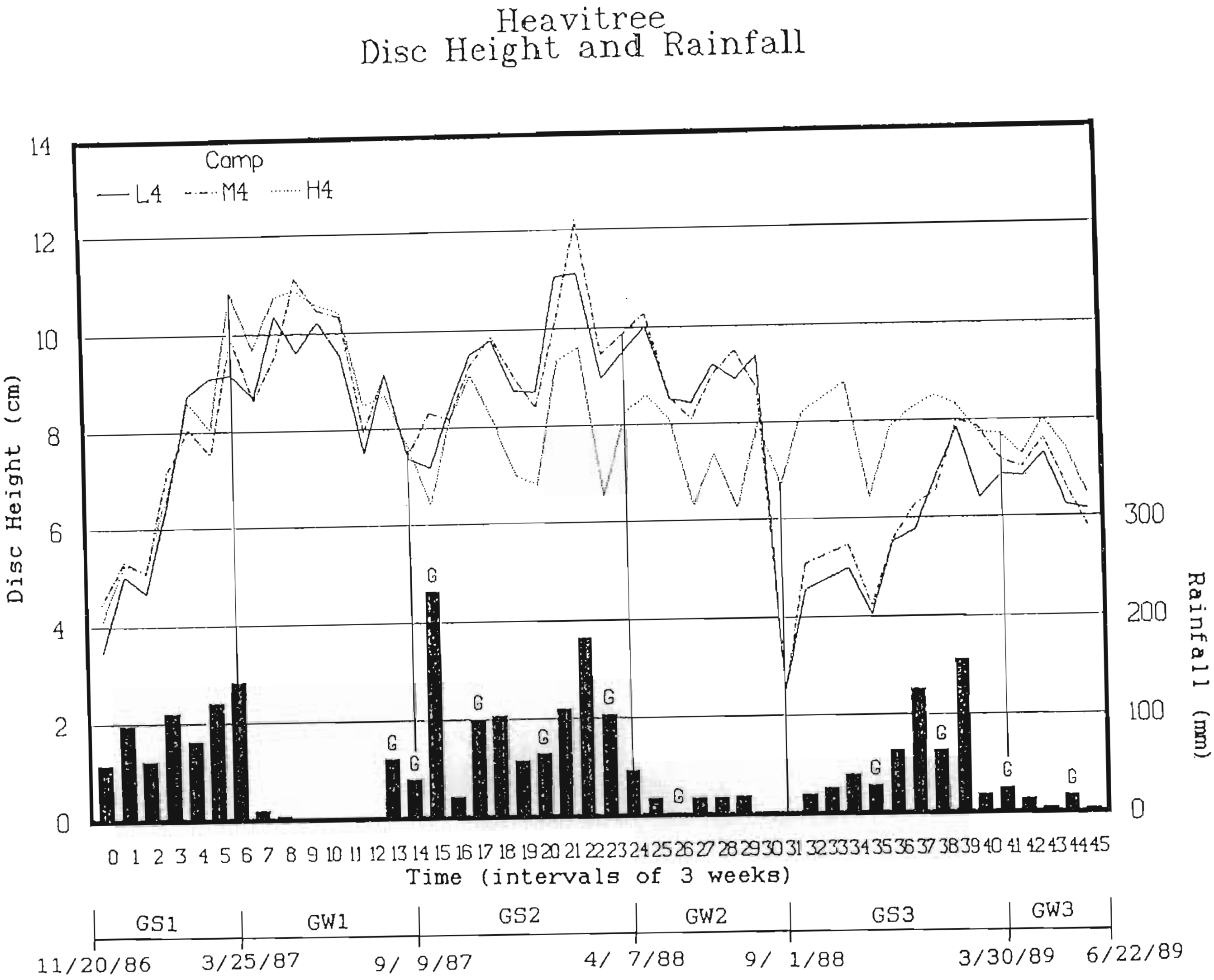


Fig. 8.5a. Disc height (cm) at each measuring period for each camp of group 4 at Site 4. Also indicated is the rainfall (mm) that occurred during each period and the periods during which each camp in the group was grazed (G). The vertical lines show the grass summers (GS) and grass winters (GW) (which are labelled below the X-axis). (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

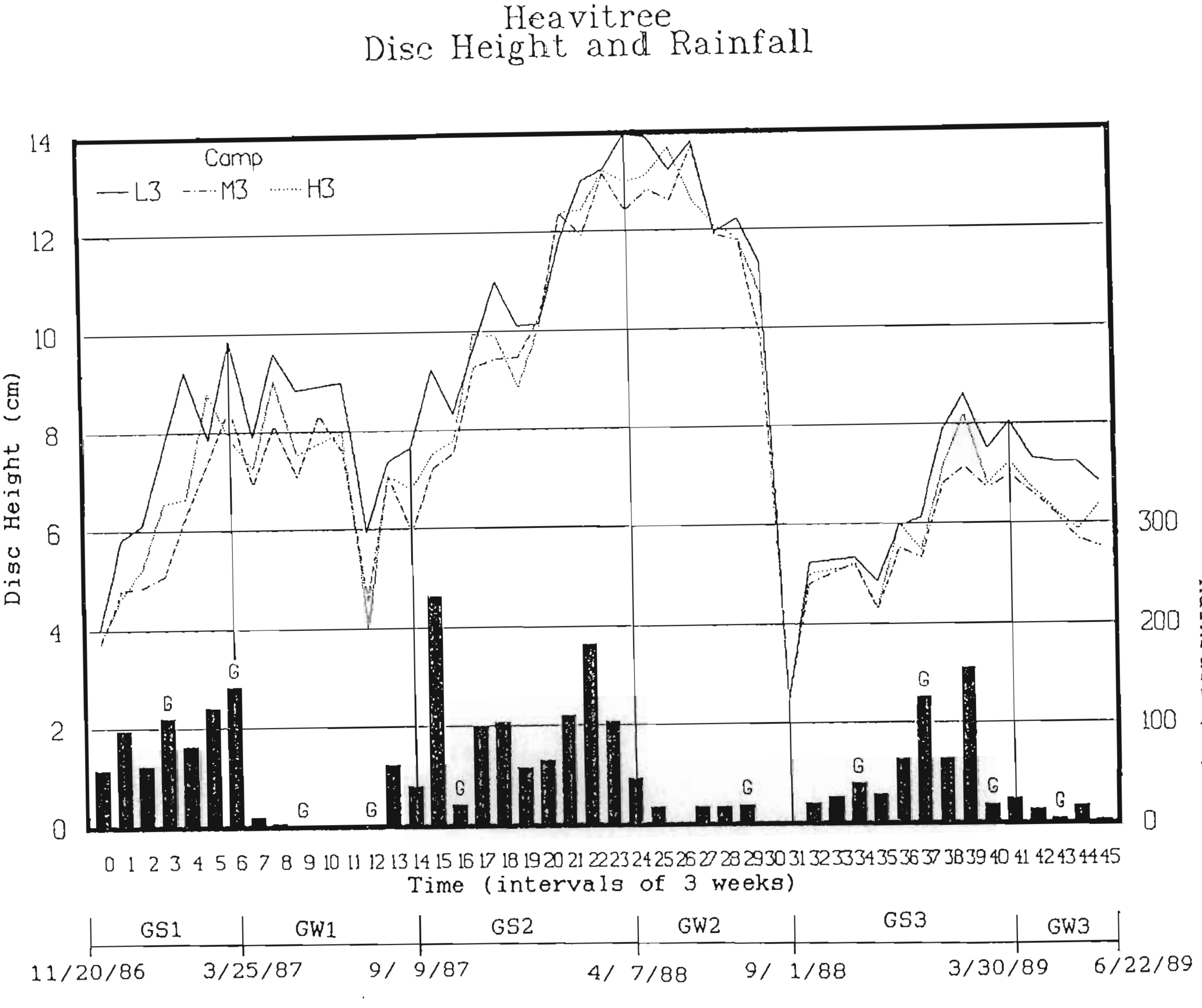


Fig. 8.5b. Disc height (cm) at each measuring period for each camp of group 3 at Site 4. Also indicated is the rainfall (mm) that occurred during each period and the periods during which each camp in the group was grazed (G). The vertical lines show the grass summers (GS) and grass winters (GW) (which are labelled below the X-axis). (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

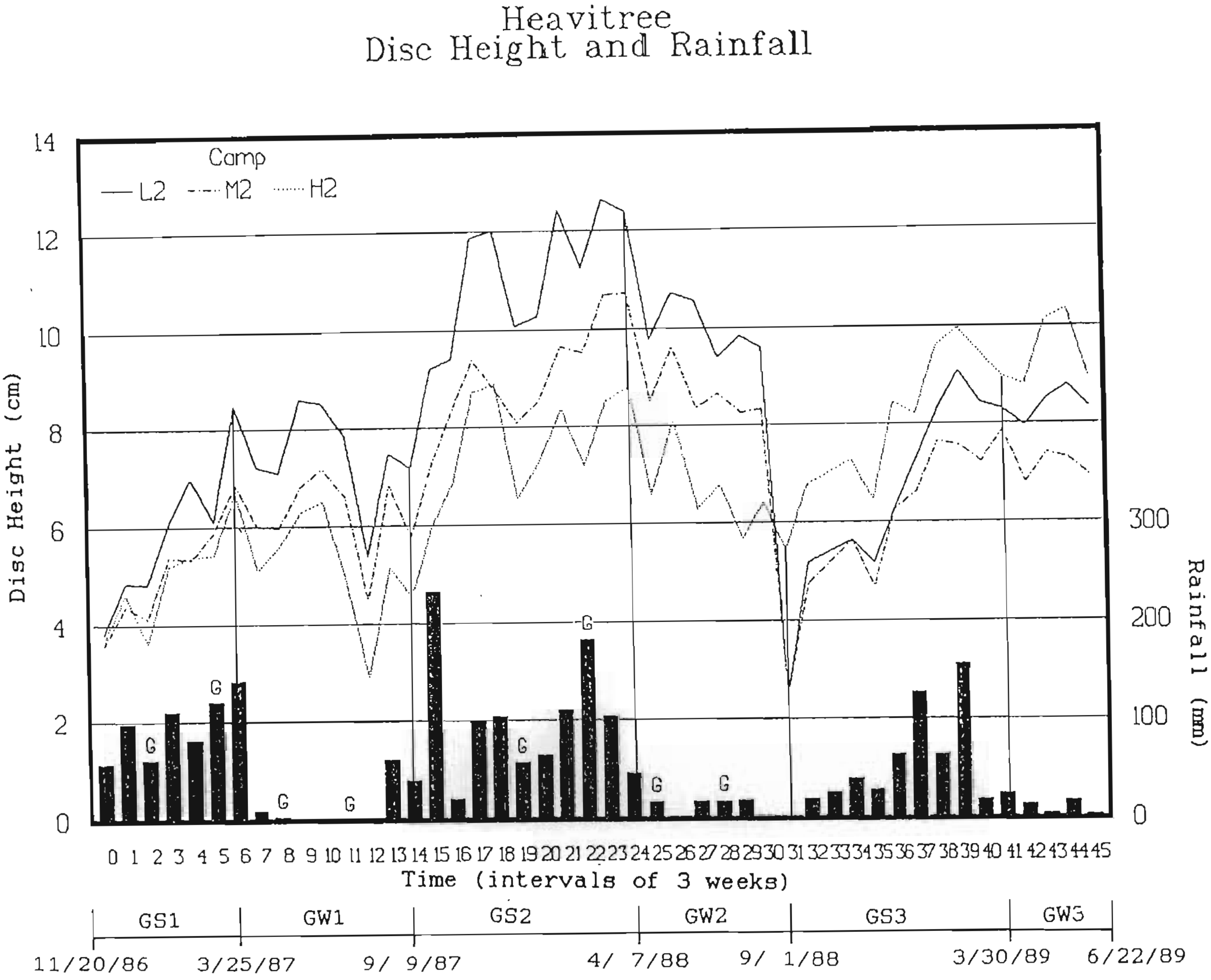


Fig. 8.5c. Disc height (cm) at each measuring period for each camp of group 2 at Site 4. Also indicated is the rainfall (mm) that occurred during each period and the periods during which each camp in the group was grazed (G). The vertical lines show the grass summers (GS) and grass winters (GW) (which are labelled below the X-axis). (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

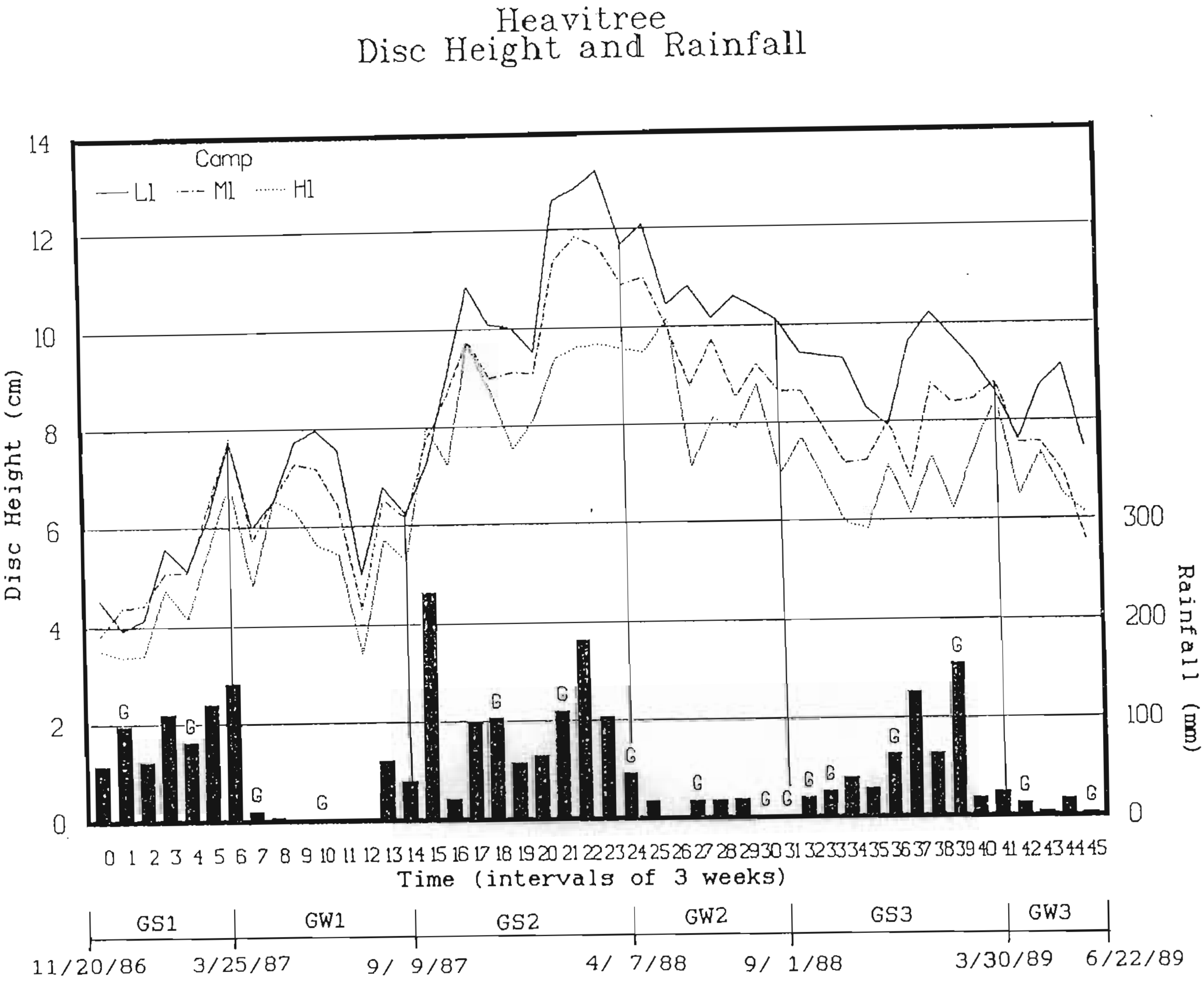


Fig. 8.5d. Disc height (cm) at each measuring period for each camp of group 1 at Site 4. Also indicated is the rainfall (mm) that occurred during each period and the periods during which each camp in the group was grazed (G). The vertical lines show the grass summers (GS) and grass winters (GW) (which are labelled below the X-axis). (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

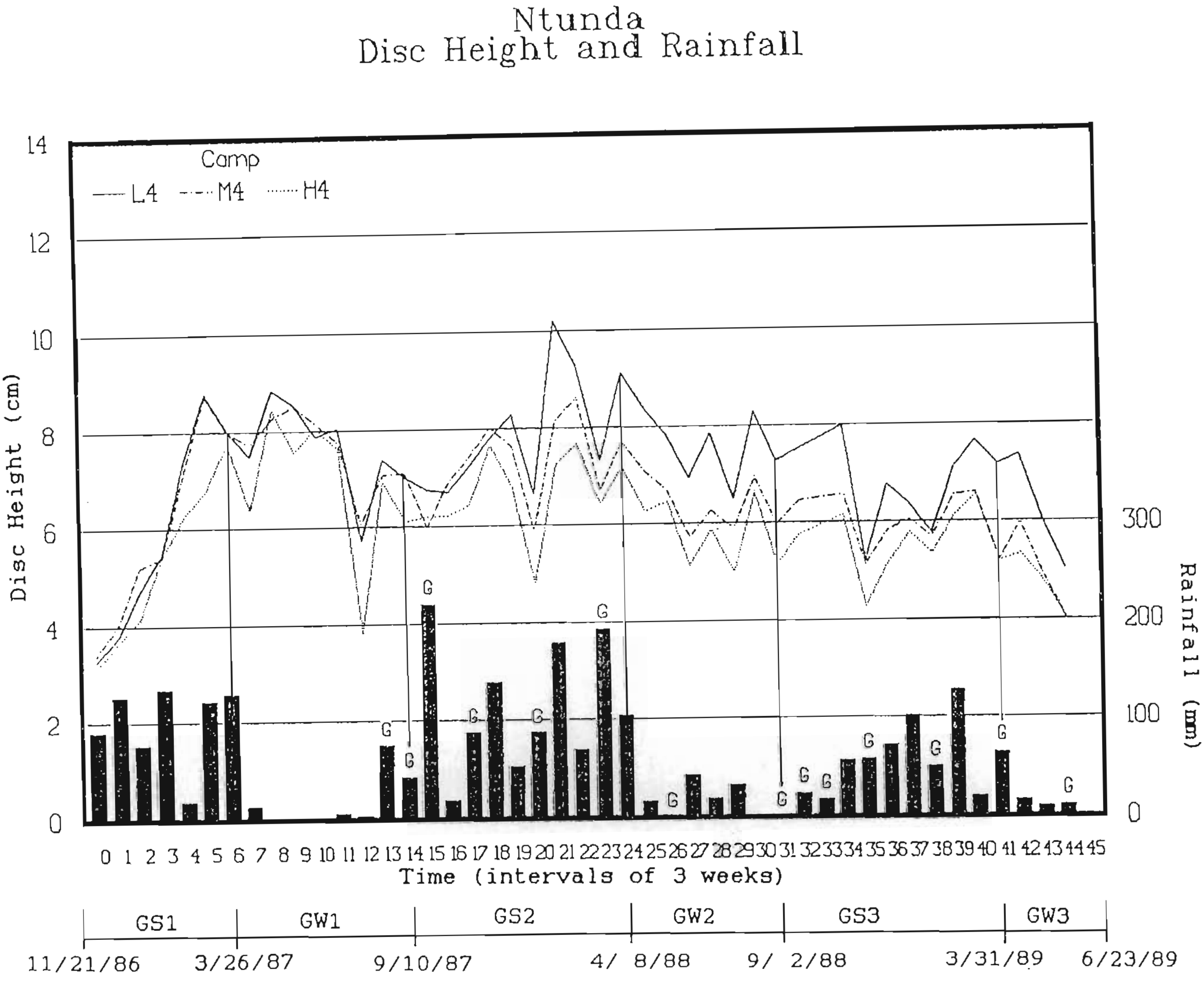


Fig. 8.6a. Disc height (cm) at each measuring period for each camp of group 4 at Site 5. Also indicated is the rainfall (mm) that occurred during each period and the periods during which each camp in the group was grazed (G). The vertical lines show the grass summers (GS) and grass winters (GW) (which are labelled below the X-axis). (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

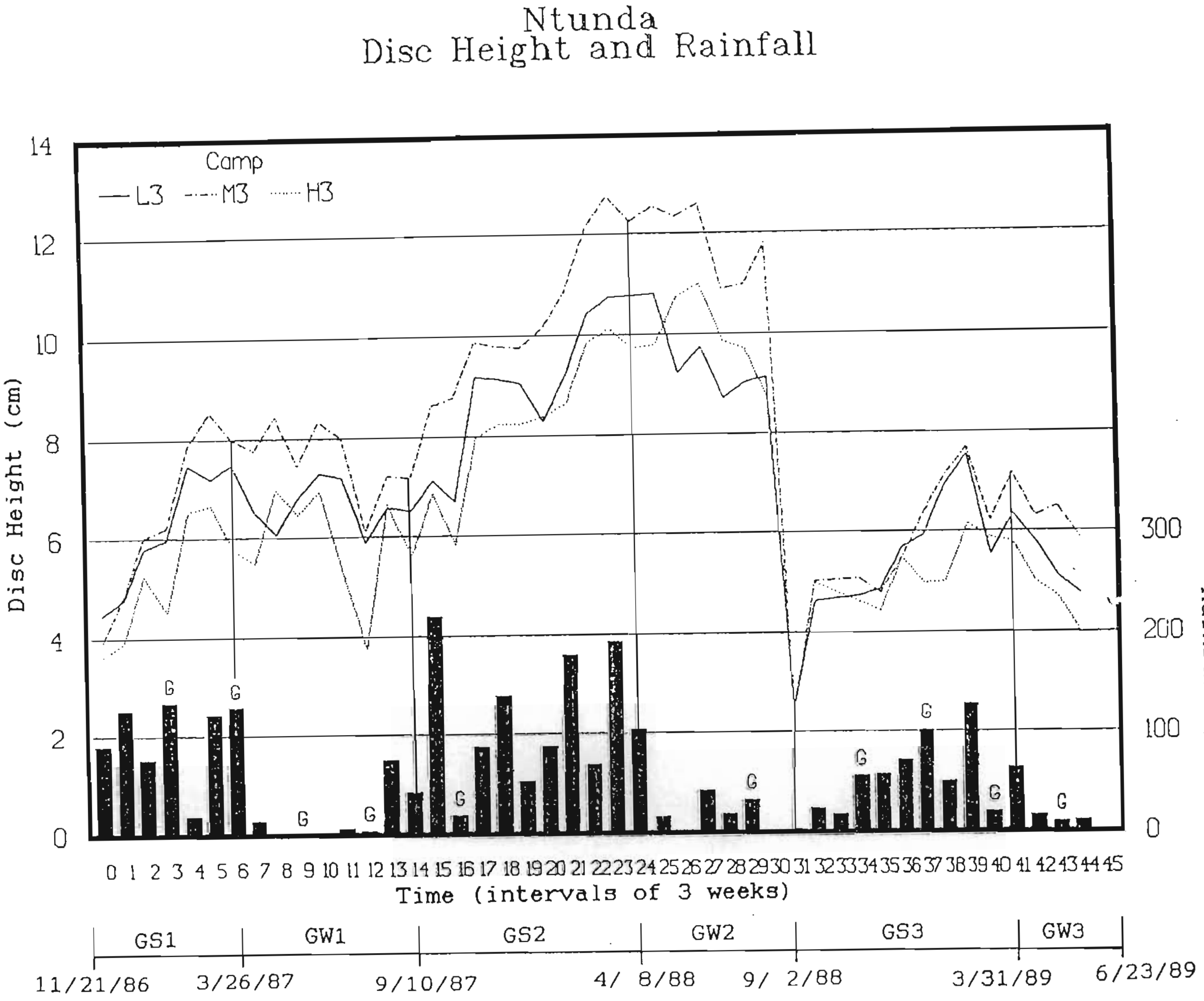
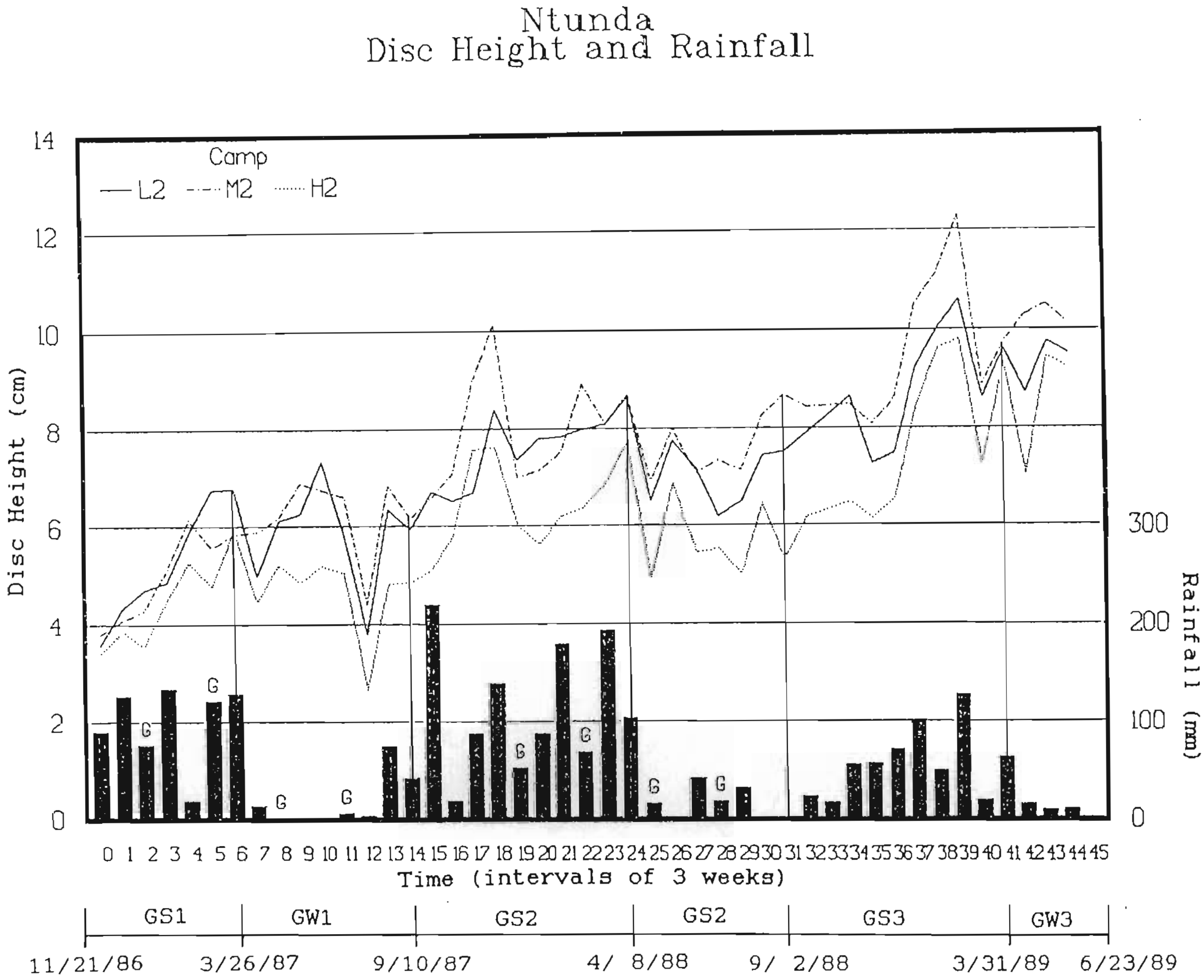


Fig. 8.6b. <u>Disc height (cm)</u> at each measuring period for each camp of <u>group 3 at Site 5</u>. Also indicated is the rainfall (mm) that occurred during each period and the periods during which each camp in the group was grazed (G). The vertical lines show the grass summers (GS) and grass winters (GW) (which are labelled below the X-axis). (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)



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Disc Height and Rainfall

Fig. 8.6c. Disc height (cm) at each measuring period for each camp of group 2 at Site 5. Also indicated is the rainfall (mm) that occurred during each period and the periods during which each camp in the group was grazed (G). The vertical lines show the grass summers (GS) and grass winters (GW) (which are labelled below the X-axis). (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

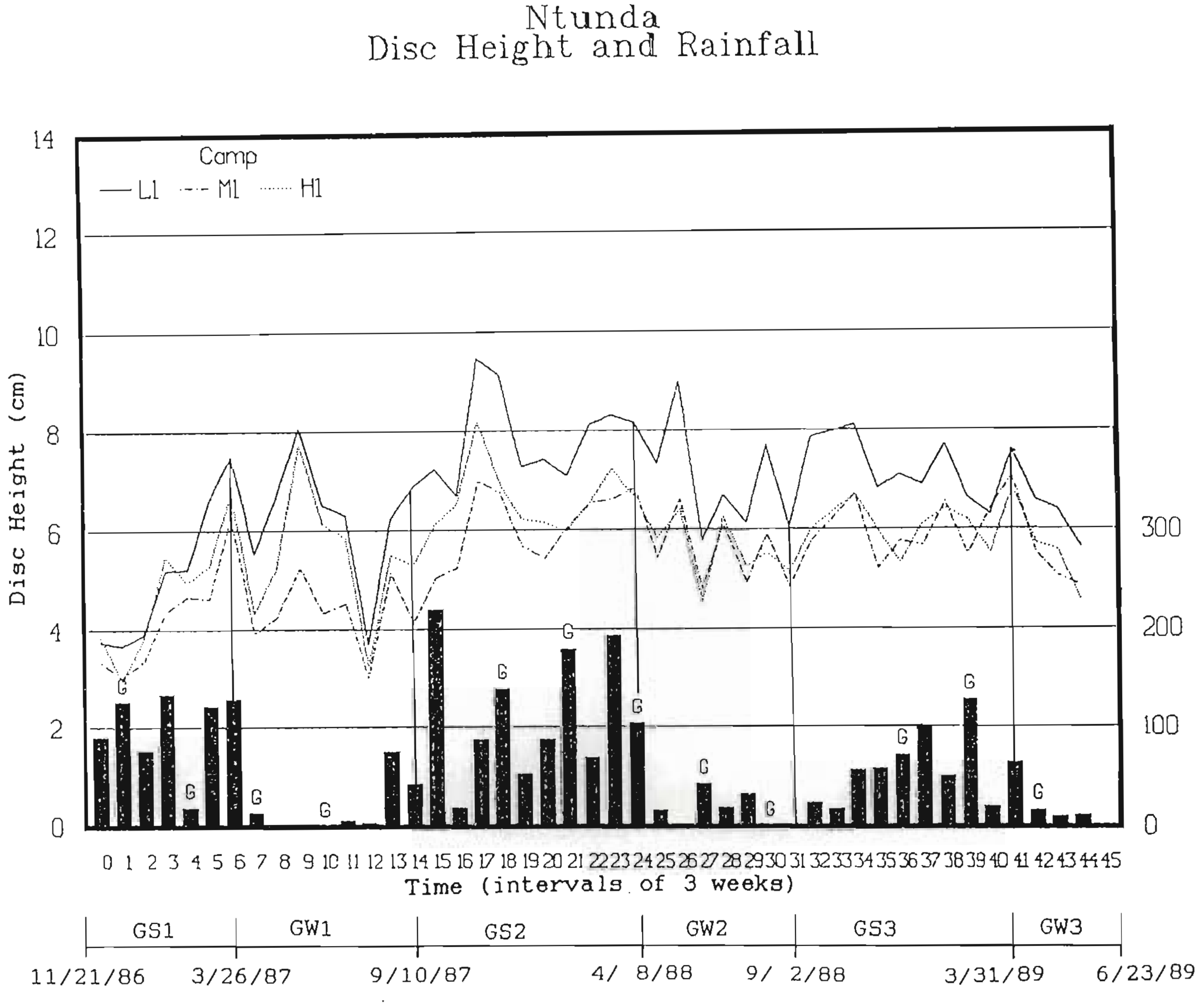


Fig. 8.6d. Disc height (cm) at each measuring period for each camp of group 1 at Site 5. Also indicated is the rainfall (mm) that occurred during each period and the periods during which each camp in the group was grazed (G). The vertical lines show the grass summers (GS) and grass winters (GW) (which are labelled below the X-axis). (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

result of burning. It should be noted that because all the camps were burnt at the start of the trials, it was decided not to burn camps that had been rested during the first summer at the end of the following winter. The reason for this decision was that annual burning is not usually recommended in the Tall Grassveld. It was feared that to burn camps in two successive years may have resulted in a loss of credibility of the trials among the farmers. Although there were several camps with a high residual HM at the end of the first winter, there was not much moribund grass. However, one camp (Camp L3 at Site 3) was burnt because of the exceptionally high residual HM (> 10 cm) recorded there. In retrospect, in view of the exceptionally wet year that followed, it would have been better to burn the camps which had rested during the first summer.

At the end of the winter following the second summer, there was so much residual herbage on some camps that it was feared that there would be an excessive accumulation of moribund material. It was therefore decided that more camps required burning than just those camps which had been rested during the second summer. The criterion for burning was arbitrarily chosen, but based on the "take half leave half" philosophy. Thus if more than half the potential available HM was left at the end of the winter i.e. HM > 3000 kg/ha or a DH >8 cm, the camp was burnt. (It should be noted that 4000 kg/ha was estimated by Turner (1988) to be the highest possible accumulation of HM for the Tall Grassveld and 2000 kg/ha to be the grazing cut-off. 3000 kg/ha was therefore assumed to represent the level at which half the potential available herbage to animals would remain.) The result was that at Site 3, three camps from the light stocking rate treatment and two each from the moderate and heavy treatments were burnt. At Site 4, three camps from each of the light and moderate treatments and two from the heavy treatments were burnt. At Site 5 only one camp from each treatment was burnt.

For the same reasons given for the Lowveld (Section 4.3), the paired data for calibrating the disc meter were combined and a general calibration curve was developed for the Tall Grassveld which is as follows:

$$H = 326 + 385{,}5D \qquad r^2 = 0{,}67 \quad **$$

where
H = Herbage mass (kg/ha)
D = Disc height (cm)

Once again, it should be noted that by using a single general calibration curve for herbage mass on disc height, the changes in HM will follow an identical pattern to the changes in DH.

The grass summers and winters which were identified for the three seasons are shown in Figs 8.4, 8.5 and 8.6. From these figures some general observations may be made.

a. DH followed closely the pattern in rainfall. DHs for the second summer were therefore generally markedly higher than for either the first and third summers.

b. As a general rule, the DHs for Sites 3 and 4 (veld considered to be in good condition) were very much higher than for Site 5 (veld considered to be in moderate condition).

c. The lengths of the grass summers and grass winters varied between seasons.

d. The depressive effect that stocking rate had on HM is particularly noticeable for veld in moderate condition (Fig. 8.6) and for the moderate and heavy stocking rate treatments.

e. Often mean DHs of between 3 and 4 cm (or a HM of about 1482 to 1868 kg/ha) were recorded towards the end of winter. This range of HM is, however, lower than the 2000 kg/ha grazing cut-off suggested by Turner (1988). When camps were grazed to a DH of about 4 cm or a HM of 1868 kg/ha, they were grazed down to a height consistent with the concept of a grazing cut-off suggested by Turner (1988). The discrepancy between this value and the 2000 kg/ha suggested earlier by Turner (1988) may lie in the use of the general calibration equation in these analyses and not the specific calibration curve for that time used by Turner (1988).

8.4 CHANGES IN ANIMAL PERFORMANCE

The mean animal cumulative mass gains (CMGs) for Sites 3, 4 and 5 are presented in Figs 8.7, 8.8 and 8.9 respectively. From these data changes in mean IAP with time over 45 time periods (these periods coincide with those for the disc meter data) are clearly seen. The animal summers and winters which were identified for the three seasons are shown in these figures.

Polynomials were fitted to the CMG data for each stocking rate at each site (Figs 8.10, 8.11 and 8.12 for Sites 3, 4 and 5 respectively). Stocking rates (LSU/ha) were calculated from the fitted data using the procedure described by Turner (1988). The IAP and stocking rate data are summarised in Table 8.3.

The following should be noted with respect to animal performance in the Tall Grassveld.

a. The strong and consistent effect of stocking rate on IAP which was anticipated for all seasons did not materialise (Table 8.3), even if total CMG which occurred over the first 43 periods under evaluation

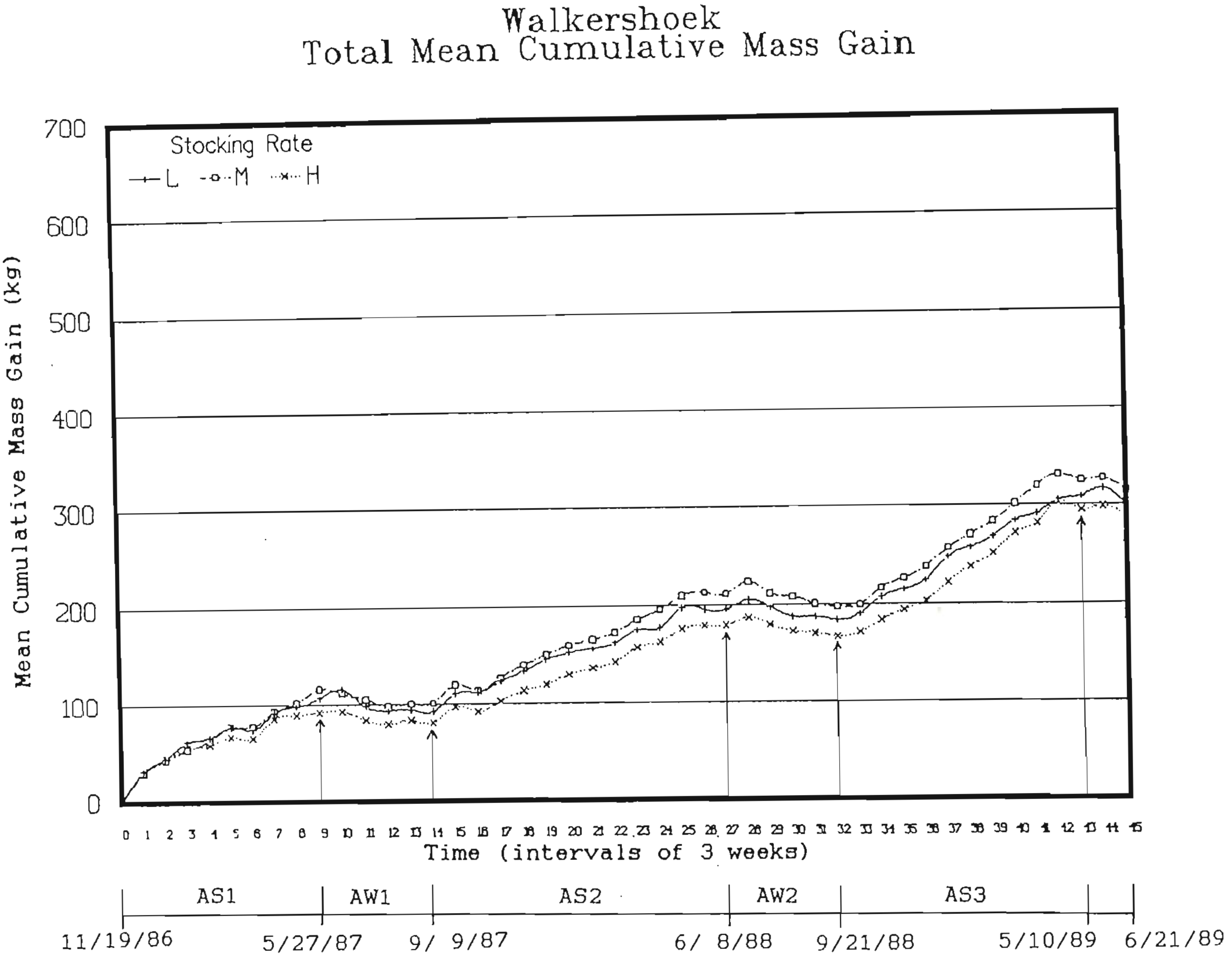


Fig. 8.7. The mean cumulative mass gain (kg) over the three year experimental period at Site 3 for each stocking rate treatment. The vertical arrows show the animal summers (AS) and animal winters (AW) (which are labelled below the X-axis). (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

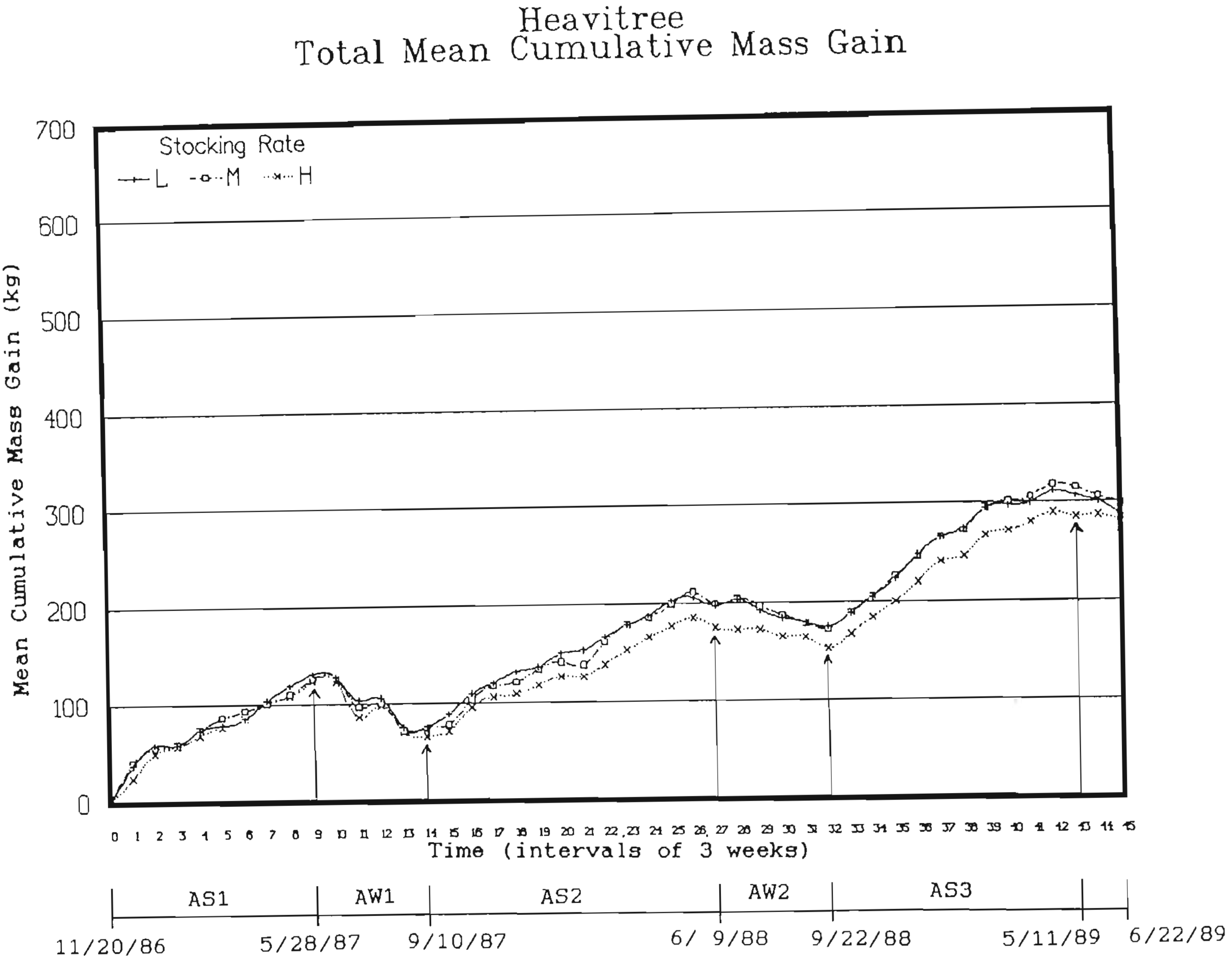


Fig. 8.8. The <u>mean cumulative mass gain (kg)</u> over the three year experimental period at <u>Site 4</u> for each stocking rate treatment. The vertical arrows show the animal summers (AS) and animal winters (AW) (which are labelled below the X-axis). (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

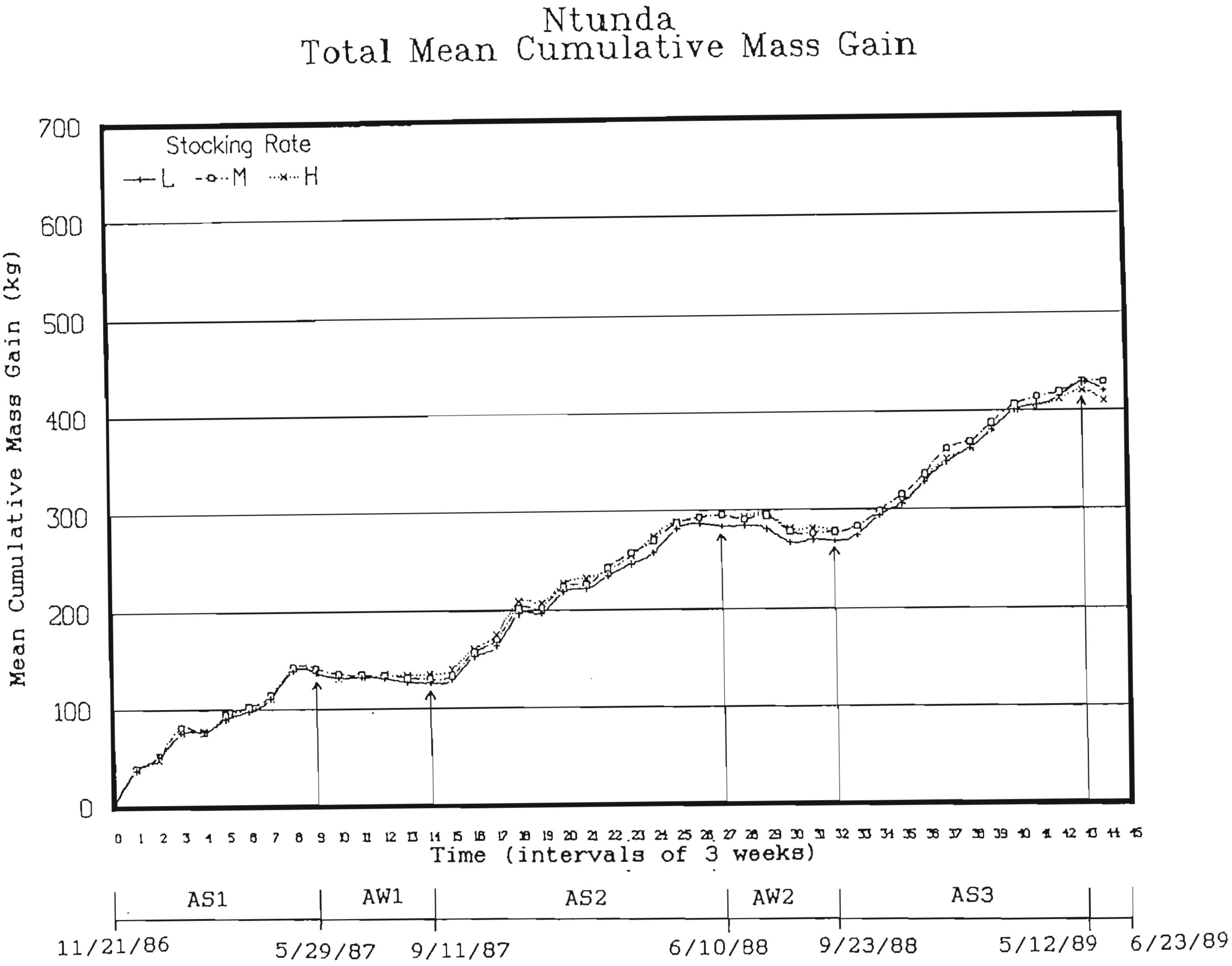


Fig. 8.9. The mean cumulative mass gain (kg) over the three year experimental period at Site 5 for each stocking rate treatment. The vertical arrows show the animal summers (AS) and animal winters (AW) (which are labelled below the X-axis). (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

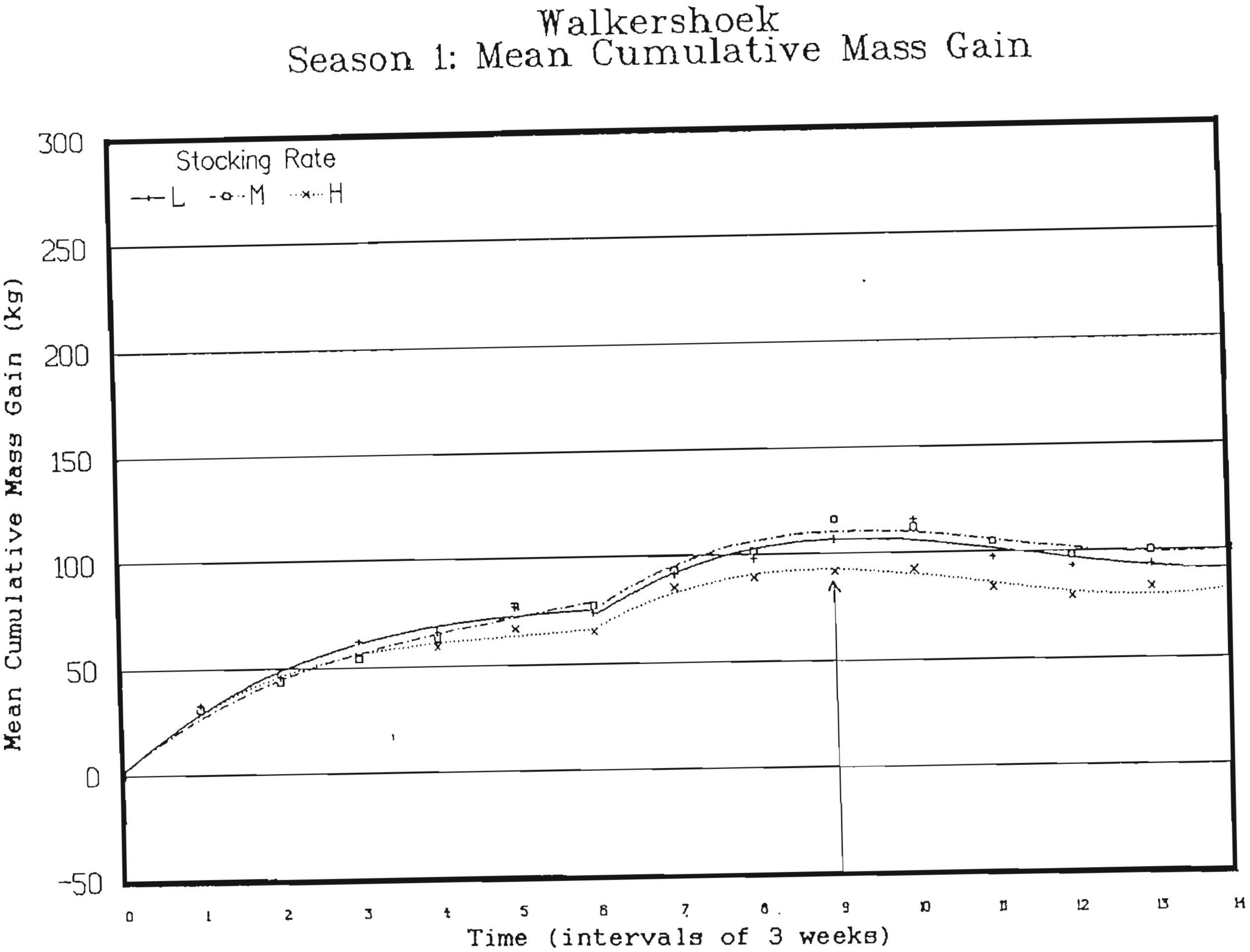


Fig. 8.10a. The fitted mean cumulative mass gain (kg) over the first summer and winter at Site 3 for each stocking rate treatment. The periods are equivalent to the corresponding periods in Fig. 8.7. The vertical arrow indicates the division between the animal summer and winter. (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

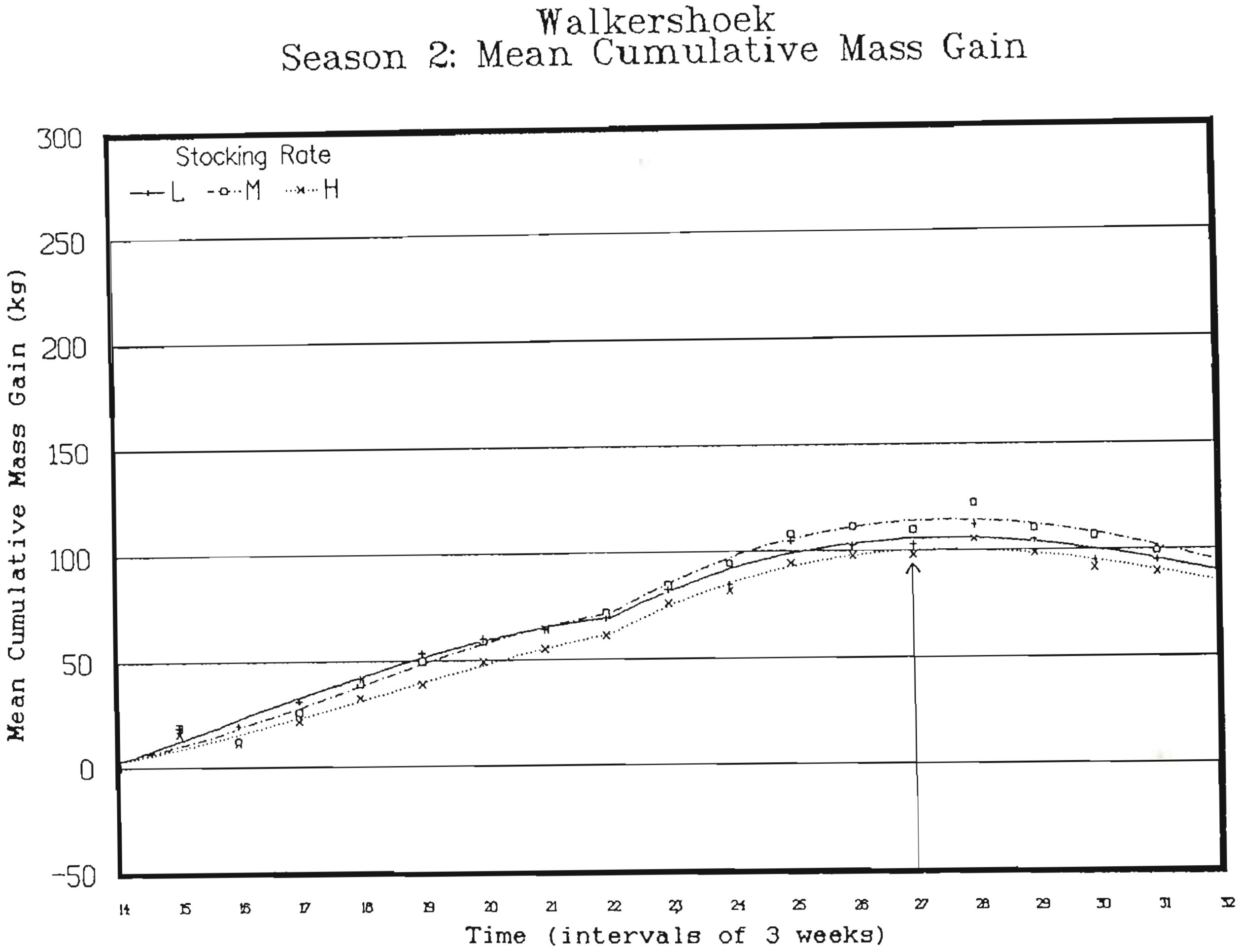


Fig. 8.10b. The fitted mean cumulative mass gain (kg) over the second summer and winter at Site 3 for each stocking rate treatment. The periods are equivalent to the corresponding periods in Fig. 8.7. The vertical arrow indicates the division between the animal summer and winter. (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

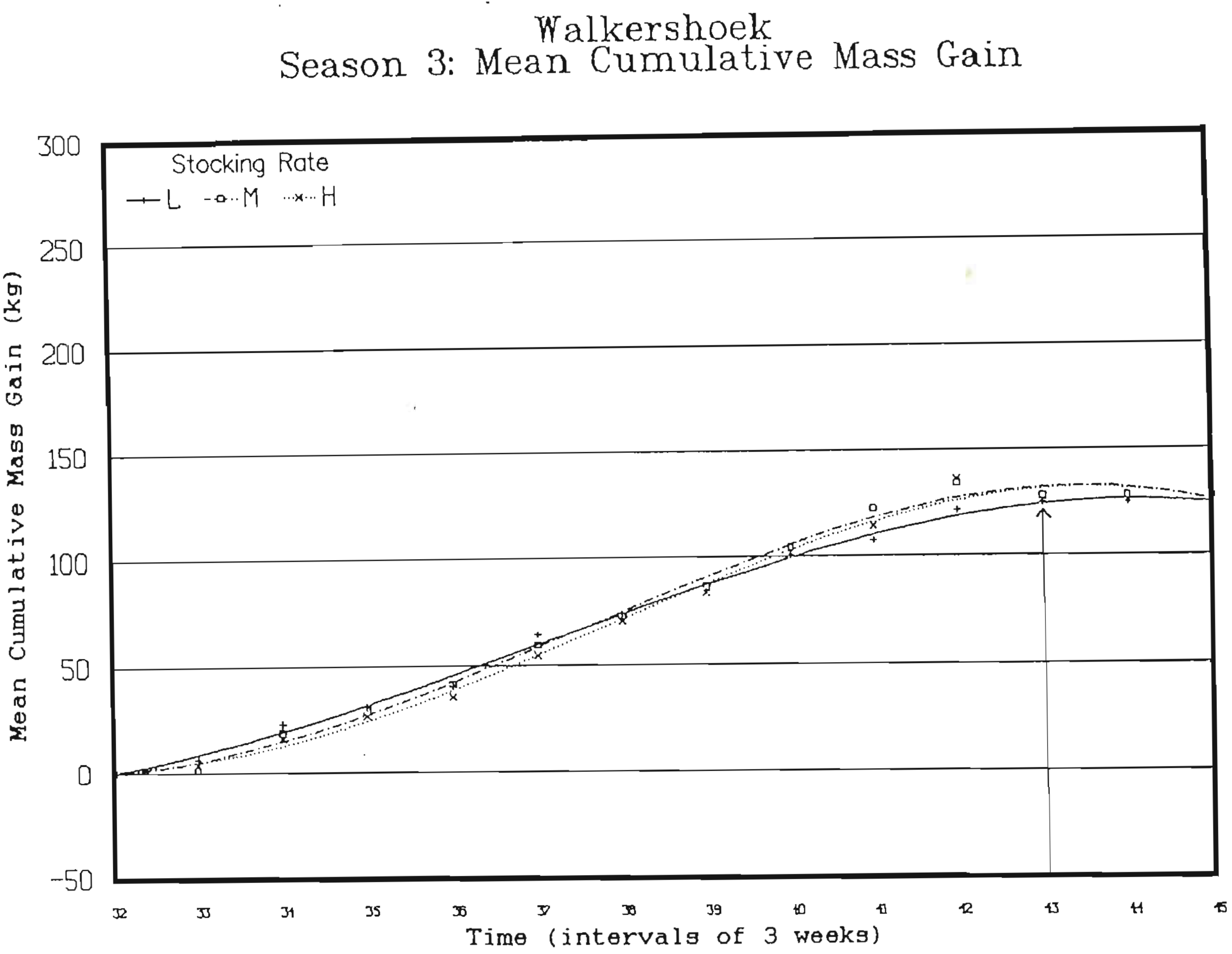


Fig. 8.10c. The <u>fitted mean cumulative mass gain (kg)</u> over the <u>third summer and the start of the third winter at Site 1</u> for each stocking rate treatment. The periods are equivalent to the corresponding periods in Fig. 8.7. The vertical arrow indicates the division between the animal summer and winter. (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

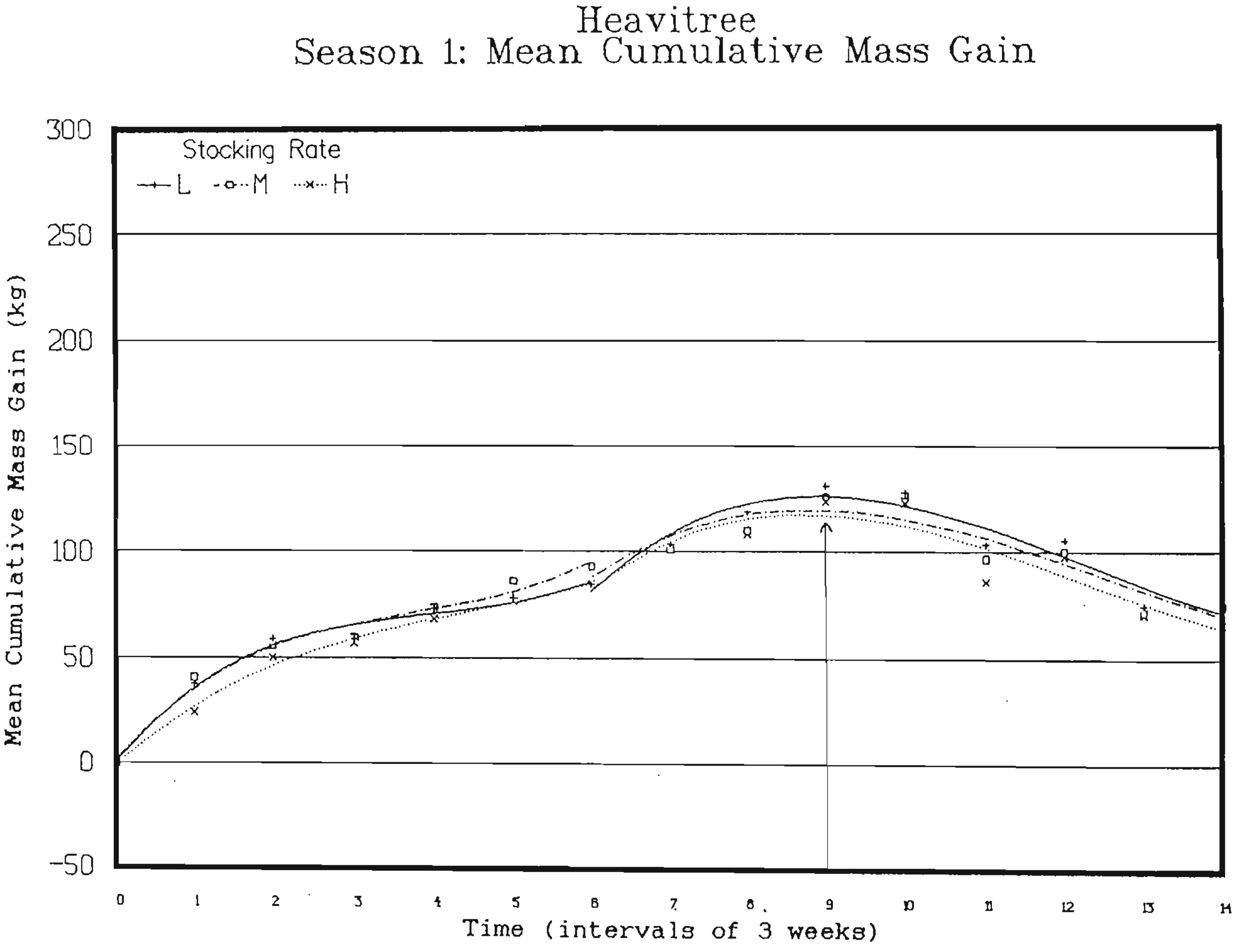


Fig. 8.11a. The fitted mean cumulative mass gain (kg) over the first summer and winter at Site 4 for each stocking rate treatment. The periods are equivalent to the corresponding periods in Fig. 8.8. The vertical arrow indicates the division between the animal summer and winter. (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

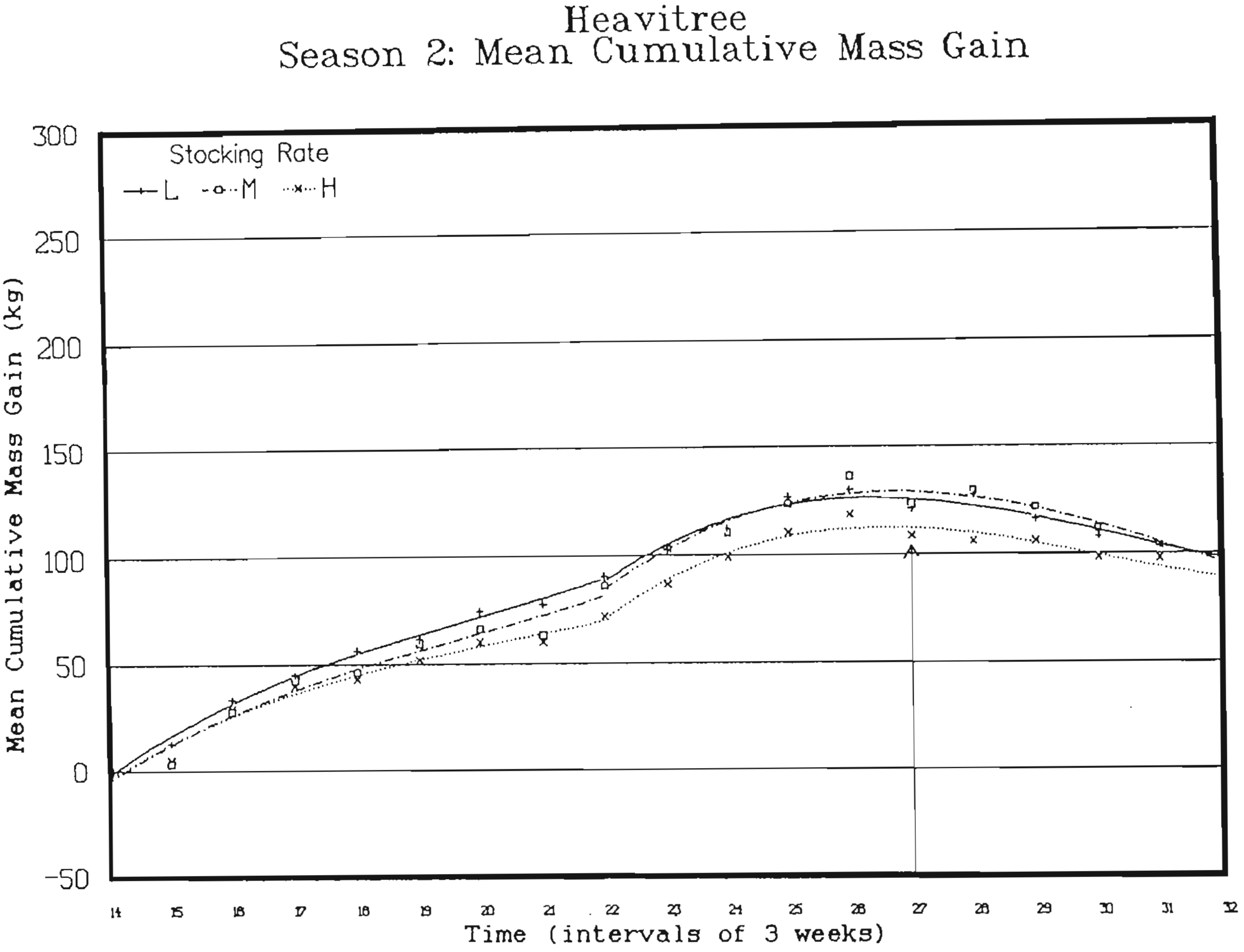


Fig. 8.11b. The fitted mean cumulative mass gain (kg) over the second summer and winter at Site 4 for each stocking rate treatment. The periods are equivalent to the corresponding periods in Fig. 8.8. The vertical arrow indicates the division between the animal summer and winter. (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

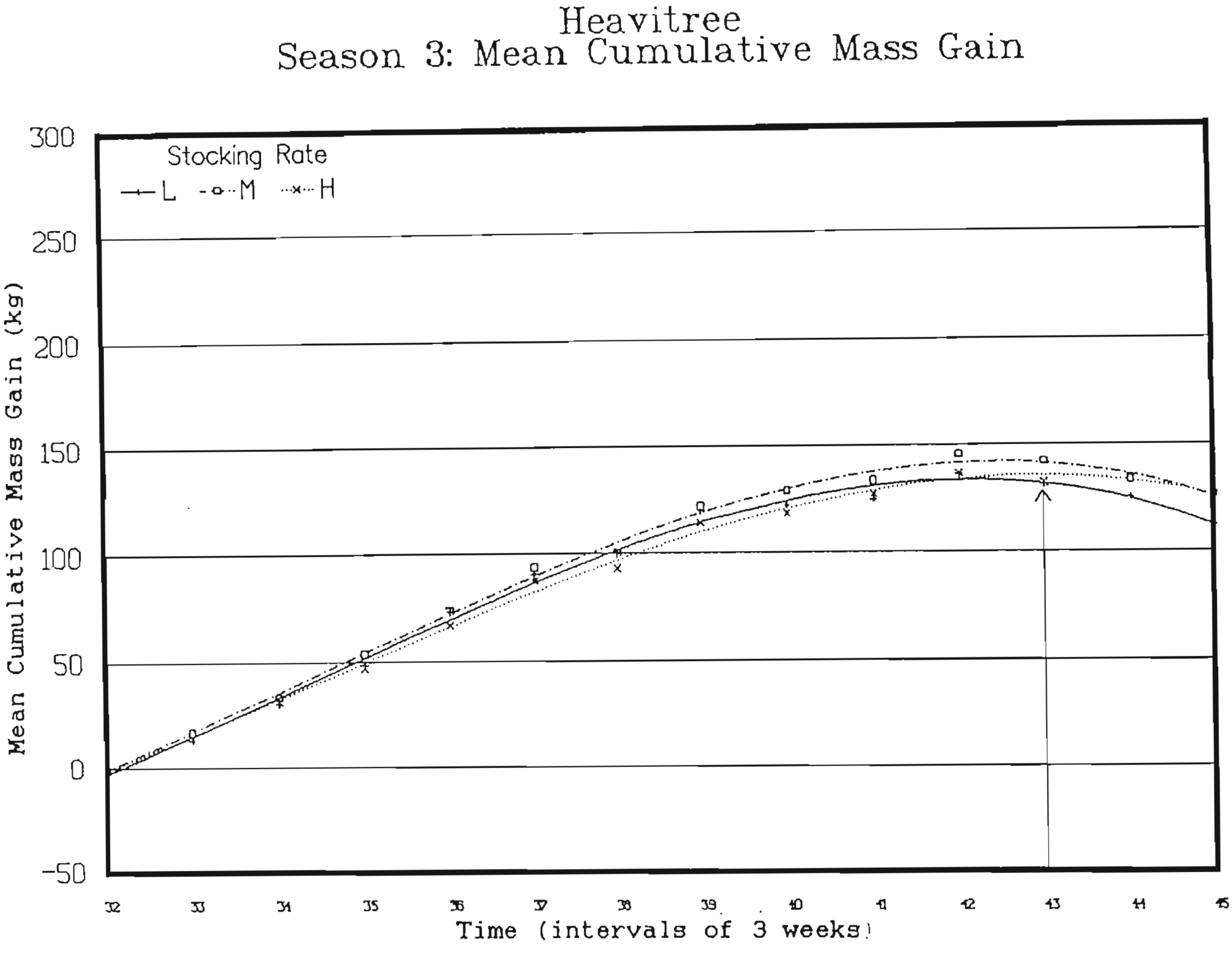


Fig. 8.11c. The fitted mean cumulative mass gain (kg) over the third summer and the start of the third winter at Site 4 for each stocking rate treatment. The periods are equivalent to the corresponding periods in Fig. 8.8. The vertical arrow indicates the division between the animal summer and winter. (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

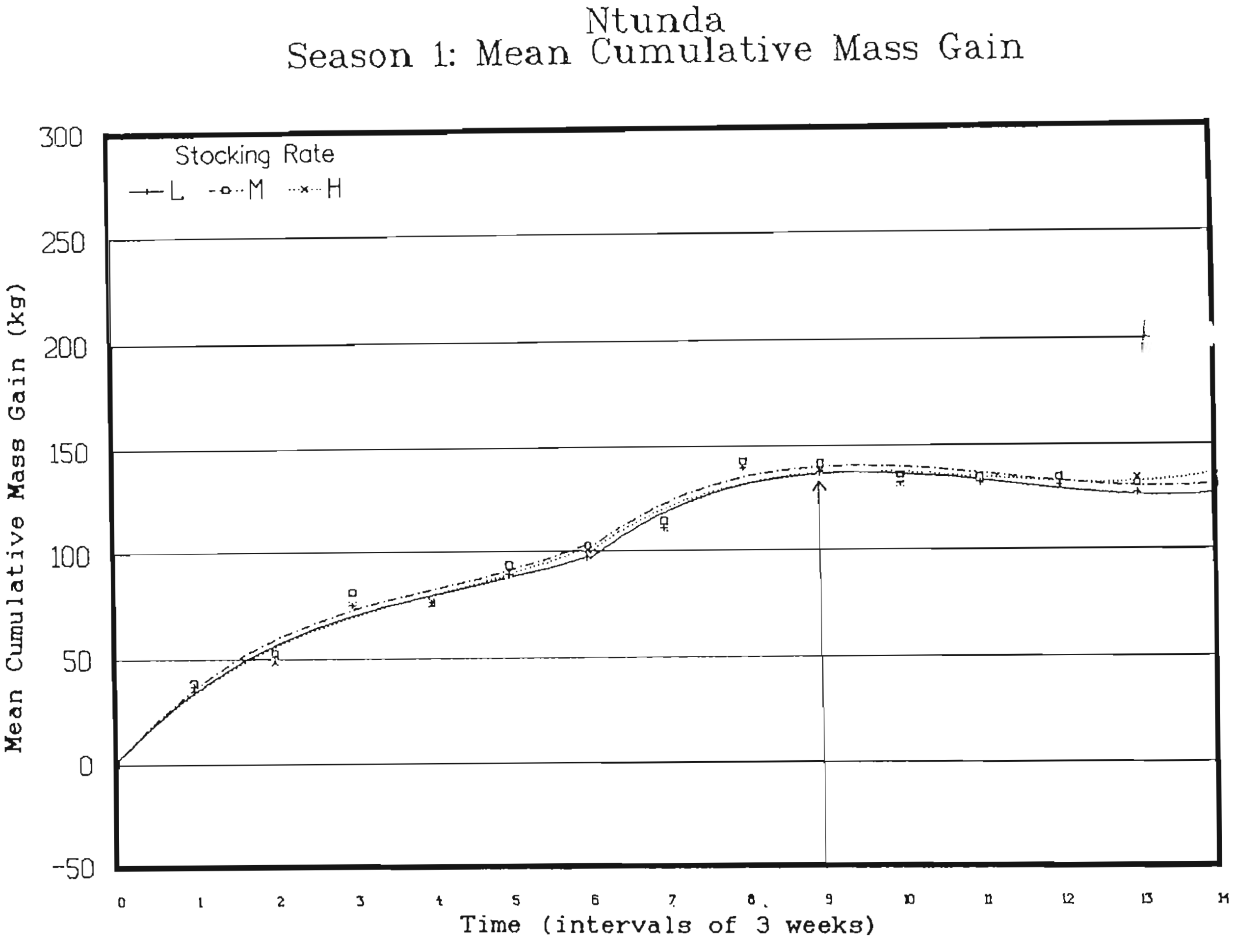


Fig. 8.12a. The fitted mean cumulative mass gain (kg) over the first summer and winter at Site 5 for each stocking rate treatment. The periods are equivalent to the corresponding periods in Fig. 8.9. The vertical arrow indicates the division between the animal summer and winter. (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

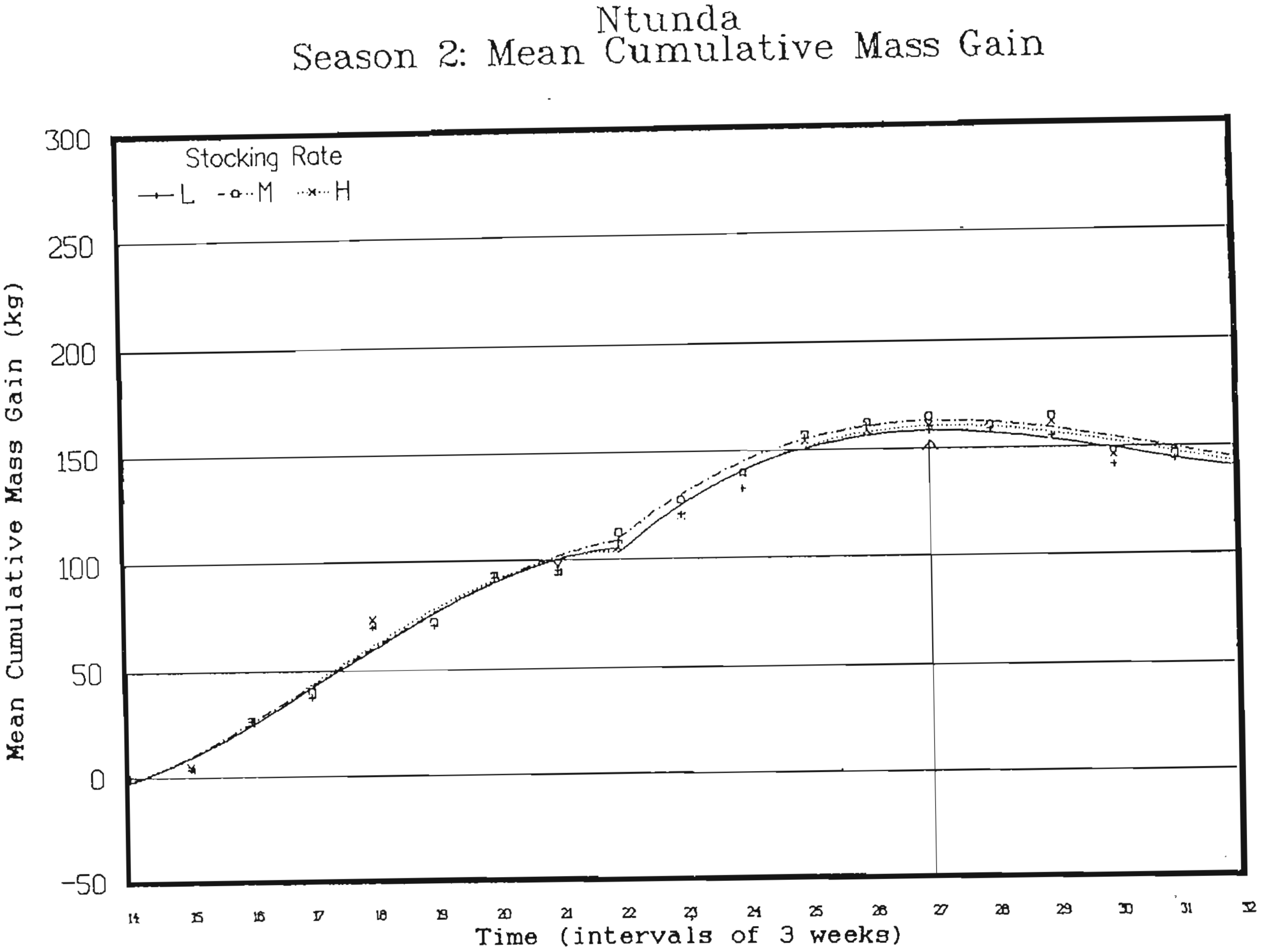


Fig. 8.12b. The <u>fitted mean cumulative mass gain (kg)</u> over the <u>second summer and winter at Site 5</u> for each stocking rate treatment. The periods are equivalent to the corresponding periods in Fig. 8.9. The vertical arrow indicates the division between the animal summer and winter. (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

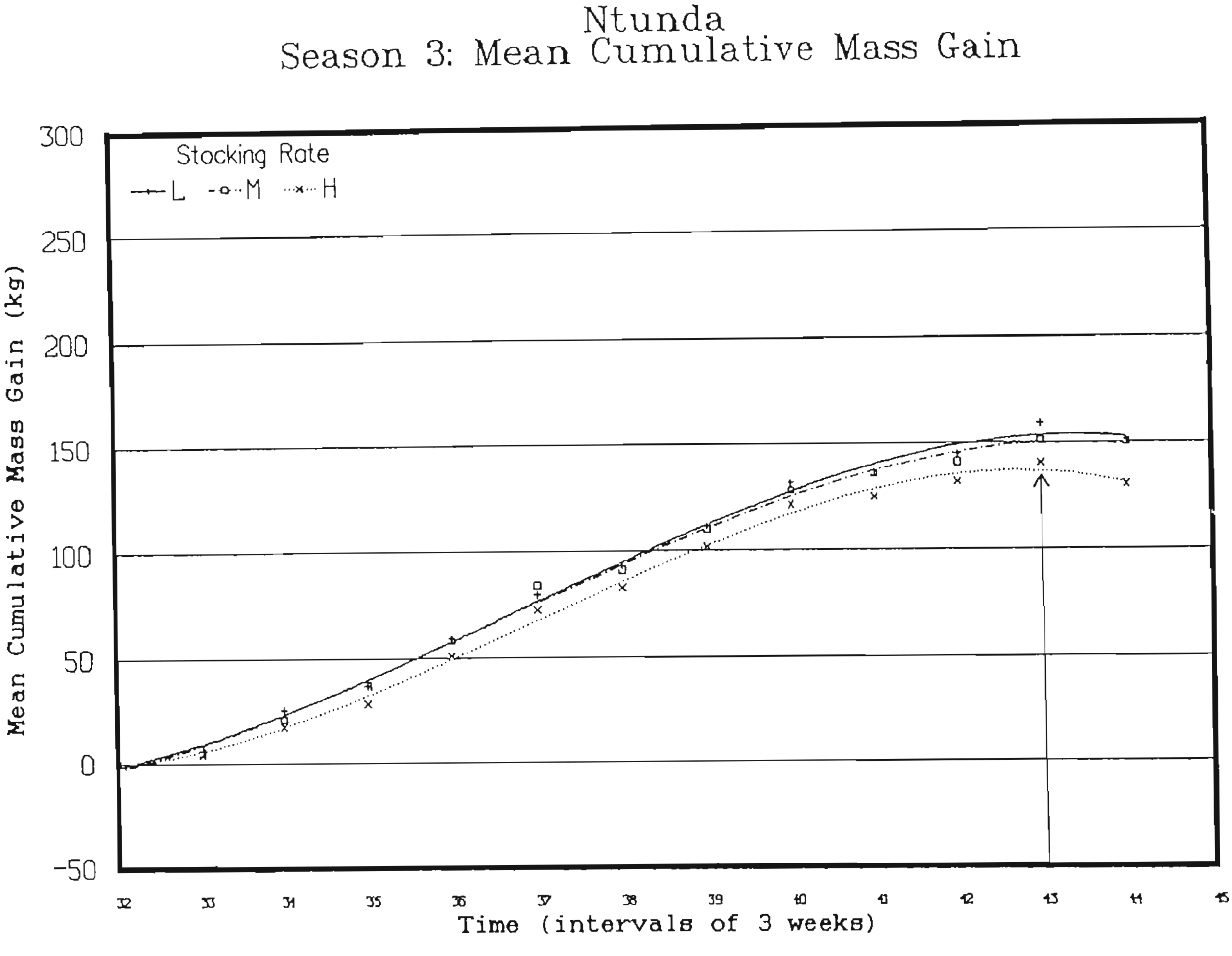


Fig. 8.12c. The fitted mean cumulative mass gain (kg) over the third summer and the start of the third winter at Site 5 for each stocking rate treatment. The periods are equivalent to the corresponding periods in Fig. 8.9. The vertical arrow indicates the division between the animal summer and winter. (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

Table 8.3 A summary of individual animal performance and stocking rate for Sites 3, 4 and 5 derived from the fitted data. (The periods coincide with those in Figures 8.10, 8.11 and 8.12 for the respective sites.) (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

Site, & Periods	Length of period of gains/ losses (weeks)	Gains/losses (kg)			Actual Stocking Rate (LSU/ha)		
		L	M	H	L	M	H
Site 3							
0 - 9	27	107	111	93	0,28	0,35	0,44
9 - 14	15	-16	-10	-10	0,15	0,19	0,26
0 - 14	42	91	101	83	0,24	0,30	0,38
14 - 27	39	106	114	100	0,27	0,35	0,46
27 - 32	15	-16	-19	-15	0,17	0,19	0,29
14 - 32	54	90	95	85	0,25	0,32	0,42
32 - 43	33	124	132	132	0,30	0,36	0,50
0 - 43	129	305	328	300	0,26	0,32	0,42
Site 4							
0 - 9	27	126	120	117	0,40	0,51	0,67
9 - 14	15	-54	-50	-53	0,23	0,29	0,40
0 - 14	42	72	70	64	0,34	0,43	0,57
14 - 27	39	126	129	112	0,31	0,39	0,52
27 - 32	15	-28	-33	-23	0,22	0,28	0,39
14 - 32	54	98	96	89	0,28	0,36	0,49
32 - 43	33	134	142	134	0,29	0,39	0,53
0 - 43	129	304	308	287	0,30	0,39	0,52
Site 5							
0 - 9	27	137	140	137	0,35	0,48	0,60
9 - 14	15	-10	- 8	- 5	0,17	0,22	0,29
0 - 14	42	127	132	132	0,29	0,39	0,49
14 - 27	39	158	163	161	0,31	0,40	0,52
27 - 32	15	-14	-18	-18	0,16	0,21	0,27
14 - 32	54	140	145	143	0,27	0,34	0,45
32 - 43	33	154	150	137	0,32	0,40	0,50
0 - 43	129	421	427	412	0,29	0,37	0,47

(which included summer and winter gains) (Figs 8.7, 8.8 and 8.9 and Table 8.3) are considered.

b. The length of time over which animals gained mass varied between seasons but remained consistent between stocking rate treatments and between sites within a season (Figs 8.10, 8.11 and 8.12 and Table 8.3).

c. A mid-season decline in IAP occurred in the first two seasons but not in the third season. This is probably related to herbage quality and to the time in the season at which rumen stimulating licks were made available.

Point c. above warrants further discussion. In the first year a rumen stimulating lick was made available in the last week of March (which is common practise in the area). The availability of the lick appeared to give rise to a second and marked phase of renewed animal gain. In the second season, when grass growth was exceptional due to the extremely high rainfall, a decline in IAP was detected by the end of December. Having seen the positive effect of the licks on IAP in the first season, rumen stimulating lick was made available from the end of January. The effect was again marked. In the third season, although grass grew more slowly, it was decided to make lick available from the end of February. The result was that there was no mid-season decline in IAP.

The prediction of the onset of a mid-season decline in IAP in any particular season would greatly facilitate the strategic use of rumen stimulating licks in these areas. Quantity was not limiting to animal performance in any of the three seasons under consideration. Indeed, it appeared that these mid-season declines in IAP were related rather to a high rather than a low availability of forage. It was therefore decided to test this.

It was difficult to subjectively decide, from the cumulative mass gain curves, when the mid-season declines in IAP actually started. An animal performance of < 0,4 kg gain/day was therefore subjectively chosen as the level which would indicate the start of these declines. By calculating daily gains (also used to calculate stocking rate), the dates at which animal performance declined to less than 0,4 kg/day were determined. The herbage mass (HM) for each stocking rate treatment was calculated from the mean disc meter height of the camp being grazed at this time and of the camp grazed one period of occupation prior to this. HM was regressed against the time at which the mid-season declines in IAP started (Fig. 8.13). Data from the third season were not included in this analysis because IAP only declined to 0,4 kg/day much later in the season relative to the previous two seasons and well after rumen stimulating licks had been made available.

The relationship was surprisingly good (r^2 = 0,71, P < 0,001). The implication of this model is that for any

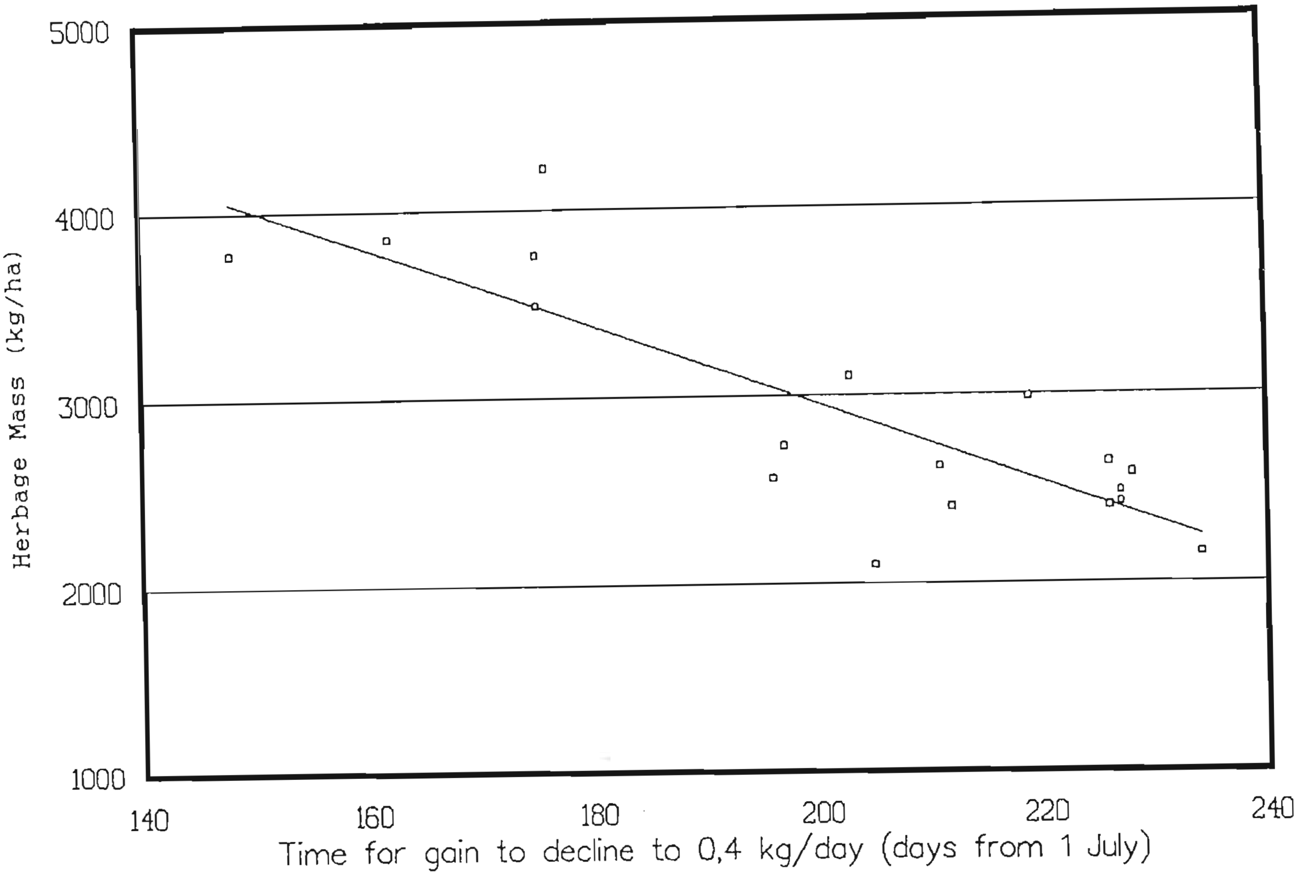


Fig. 8.13. The relationship between herbage mass (kg/ha) and time for animal gain to decline to 0,4 kg/day (days from 1st July) for the Tall Grassveld.

combination of herbage mass and time in the season below the regression line, individual animal performance will be > 0,4 kg. When stocking rate was included as a factor using multiple linear regression analysis, it was shown to have had no significant effect on the time at which the mid-season decline in individual animal performance commenced.

To determine whether herbage mass influenced the time at which animals reached maintenance at the end of the summer, use was made of the same procedure described above, except HM relative to the time at which maintenance was reached was used. Three seasons data were included because rumen stimulating licks had been made available well before the times at which maintenance was achieved. The model (Fig. 8.14) ($r^2 = 0,01$, NS) shows that herbage mass had no influence on the time at which maintenance was reached.

These results are not entirely surprising. Quality of veld would be expected to decline for two reasons. First, as HM increases, so an increase in the structural components of the herbage would be expected with the result that quality would decline. This probably explains the strong effect of herbage mass on mid-season animal performance. Second, as the season progresses, a decline in quality due to physiological changes in the grass itself, irrespective of the amount of herbage, would be expected. This probably explains why herbage mass had little influence on the time at which maintenance is reached at the end of the season.

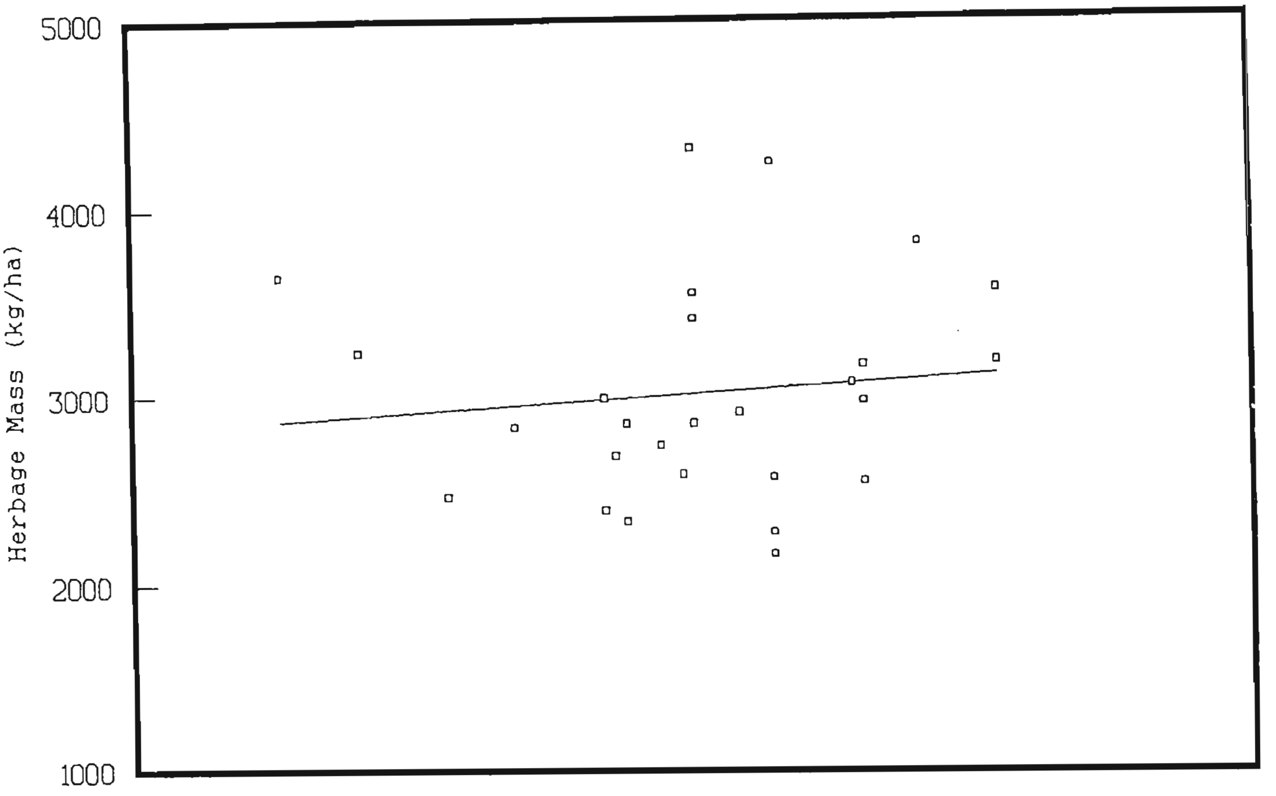


Fig. 8.14. The relationship between herbage mass (kg/ha) and time for animals to reach maintenance (days from 1st July) for the Tall Grassveld.

There is a tendency in these areas to start feeding a rumen stimulating lick later in a wet season than in a dry season. There are two possible reasons for this. In a wet season there is usually sufficient grass (and no necessity is seen to supplement animals) and there is a management problem related to keeping the lick dry (and therefore feeding a lick is too much of an inconvenience). In a dry year there is often a shortage of grass (and therefore a necessity is seen to supplement animals) and the problem related to keeping the licks dry is much reduced (and so also much of the inconvenience). However, the function of a rumen stimulating lick is to enable the animal to make better use of low quality food and it is therefore a true <u>supplement</u> and not a <u>substitute</u> feed. If the lick is fed earlier in a dry season because there is insufficient feed, then it is being incorrectly applied as a <u>substitute</u> feed. In view of the results presented above, it is clear that rumen stimulating licks should be made available according to the seasonal conditions, and particularly sward condition, and not on a fixed date or because of management inconveniences. To achieve the maximum benefit from the veld, rumen stimulating licks should be made available <u>earlier</u> in wet seasons (as early as January) than in dry seasons (when supplementation could probably be delayed until the end of March).

CHAPTER 9

HERBAGE MASS COMPONENT MODELS FOR THE TALL GRASSVELD

CHAPTER 9

HERBAGE MASS COMPONENT MODELS FOR THE TALL GRASSVELD

9.1 A MODEL FOR PREDICTING HERBAGE MASS AT THE END OF THE GRASS SUMMER FOR THE TALL GRASSVELD

Data from all three sites were used to develop the model. The total data set therefore included data from 12 camps at each of 3 sites and for each of 3 seasons (or 108 sets of data). The parameters of the model are as follows.

a. Residual HM (kg/ha) at the end of the grass summers (see Section 8.3). This was calculated from DH recorded at that time using the general calibration curve for the DM for the Tall Grassveld.

b. Rainfall (mm). This was the total which fell during the grass summers. Rain that fell in the grass winters was therefore excluded.

c. The effect of grazing during the grass summers (LSU GDs/ha) (the calculation of which is explained in Section 5.1).

d. Veld condition which was indexed simply by the sum of the proportions of _Themeda triandra_ and _Tristachya leucothrix_ (Turner, 1988).

e. Residual HM (kg/ha) at the end of the preceding grass winter. This was calculated from the DH recorded at that time using the general calibration curve for the DM for the Tall Grassveld. This was included because it is was once again felt that it would be reasonable to assume that some of this residual herbage would contribute to the HM at the end of the summer or at least that it may have been grazed so that more of the newly grown material would have survived grazing. It is important to note that the residual value included for burnt veld was 0 kg/ha despite the mean DM readings of about 2,5 cm that were obtained for recently burnt veld.

The model that was developed is as follows:

$$H_S = 2393 + 0{,}9836R_S - 9{,}28G_S + 15V + 0{,}2168H_W$$

$$r^2 = 0{,}70 \quad **$$

where

H_S = Residual herbage mass (kg/ha) at the end of the grass summer

R_S = Rainfall (mm) over the summer period

G_S = Grazing days (LSU GDs/ha) for the grass summer

V = Veld condition index (the sum of the proportions of _Themeda triandra_ and _Tristachya leucothrix_)

H_W = Residual herbage mass (kg/ha) at the end of the preceding grass winter

No advantage was gained from the development of separate models for burnt and unburnt veld (r^2 = 0,55 and 0,71 respectively) relative to the model for the combined data (r^2 = 0,70). Nor was there any advantage gained from the development of separate models for grazed and rested veld (r^2 = 0,64 and 0,72 respectively). The latter is not surprising, particularly because stocking rates are indexed by LSU GDs/ha. Even the camps that were put out to rest were grazed early in the grass summer to allow the camps that were included in the rotation for the remainder of the grass summer to come away. Thus the rested camps did not really receive a complete summer rest and were, during the grass summer, subjected to some grazing.

The analyses of Turner (1988) showed that grazing early in the season may have had a negative effect on HM at the end of the season. However, in the current analysis this was not significant. The reason for this is the different way in which stocking rate was expressed. By indexing stocking rate by LSU/ha (Turner, 1988), the implicit assumption was that all camps had received the same treatment in terms of grazing but at different times. However, no account had been taken at the time selected to establish HM of the fact that camps that had been grazed early in the rotation had been grazed for longer in total than the camps that had been grazed later in the rotation. Therefore, stocking rate (LSU/ha) and time of grazing are really combined in the present analysis in the unit LSU GDs/ha, which accounts for the differential time that camps assigned to a particular stocking rate treatment are grazed during a grass summer. Despite this, however, it should still be borne in mind that in the earlier analysis (Turner, 1988) it was shown that recovery growth was slower in camps grazed early in the spring than in those grazed later in the spring. This may be important even if the early grazed camps eventually catch up.

9.2 A MODEL FOR PREDICTING HERBAGE MASS AT THE END OF THE GRASS WINTER FOR THE TALL GRASSVELD

Data from all three sites were used to develop the model. The total data set therefore included data from 12 camps at each of 3 sites and for each of 2 seasons (or 72 sets of data). The parameters of the model are as follows.

a. HM (kg/ha) at the end of the grass winter (identified in Section 8.3). This was calculated from DH recorded at that time using the general calibration curve for the DM for the Tall Grassveld.

b. The effect of grazing (LSU GDs/ha) during the grass winter (the calculation of which is explained in Section 5.1).

c. Residual HM (kg/ha) at the end of the preceding grass summer. This was calculated from DH recorded at that time using the general calibration curve for the DM for the Tall Grassveld.

The model that was developed is as follows:

$$H_W = 580 - 5{,}6G_W + 0{,}785H_S$$

$$r^2 = 0{,}82 \quad **$$

where

H_W = Residual herbage mass (kg/ha) at the end of the grass winter

G_W = Grazing days (LSU GDs/ha) for the grass winter

H_S = Residual herbage mass (kg/ha) at the end of the preceding grass summer

9.3 DISCUSSION

Two coefficients are of interest in both the grass summer and the grass winter models.

a. Coefficients for the effect of stocking rate. In the grass summer model stocking rate (LSU GDs/ha) is shown to have a much bigger effect on HM than in the grass winter model (9,28 vs 5,6 kg/ha per LSU GD). In practice it is conceptually difficult to view an individual animal as changing over the season. It is conceptually easier to view the animal as a constant and to view the impacts it has had as changing over the season. The latter situation is reflected in these models. The mean LSUE over both the summer and the winter periods combined was used (i.e. viewing the animal as constant over the season) (see Section 5.1) but the coefficients reflect the changing impact of the animal over the season (i.e. a higher impact in summer, when in reality it has a higher substitution value, than in the winter). It should also be noted that the summer coefficient reflects closely the commonly used value of 10 kg dry matter intake per animal unit per day.

b. Coefficients for the contribution of HM carried over from the previous season to the HM at the end of the current season. From the coefficients, it is implicit that only 22% of the residual HM from the grass winter contributed to the HM at the end of the following grass summer and that about 78% of the HM at the end of the grass summer contributed to the HM at the end of the following grass winter. This result is intuitively very satisfactory, since one would anticipate a far higher rate of decay of the older material during a wet period than during a dry period.

CHAPTER 10

ANIMAL PERFORMANCE COMPONENT MODELS FOR THE TALL GRASSVELD

CHAPTER 10

ANIMAL PERFORMANCE COMPONENT MODELS FOR THE TALL GRASSVELD

Unlike the Lowveld, there is really a need only for a model to predict animal gains during the summer. The management strategies for overwintering cattle in this veld type are numerous and varied. Winter animal performance is therefore largely related to the supplementation animals receive on the veld over the winter rather than to the stocking rate. The only factor of concern therefore is that there is sufficient grass to carry animals over the winter, a problem which has already been addressed by the models presented in Chapter 9.

The relationship between stocking rate and IAP was not linear as had been expected. It was anticipated that other factors such as, for example, the length of the (summer) rainfall period, veld condition, initial animal mass and available herbage (as reflected in residual HM and which would reflect rainfall) could have had an important influence on animal performance.

Data from the three sites were used to develop the model. The total data set therefore included data from 3 stocking rate treatments at each of 3 sites and for each of 3 seasons (or 27 sets of data). The parameters of the model are as follows.

a. Animal mass gains (kg/animal) over the animal summer (Table 8.3).

b. Stocking rate (LSU/ha) for the animal summer.

c. Veld condition which was indexed simply by the sum of the proportions of _Themeda triandra_ and _Tristachya leucothrix_ (Turner, 1988).

d. Residual HM (kg/ha) at the end of the current grass summer. This was calculated from DH recorded at that time using the general calibration curve for the DM for the Tall Grassveld.

e. Mean long-term annual rainfall (mm). Relatively poor IAP was recorded at Site 3 (which had veld in excellent condition and which also has a much higher mean annual rainfall). The site is therefore probably inherently more sour because of the higher mean annual rainfall. A general positive correlation with rainfall and "sourness" of veld and a general negative correlation between IAP and "sourness" of veld are known to occur. Thus this factor (which was the second factor included in the model using stepwise multiple linear regression modelling) probably provided an indication of "sourness".

f. Time (weeks) over which gains occurred (or the length of the animal summer).

The model which was developed is as follows:

$$G = 353{,}8 - 64S_5 - 0{,}21V - 0{,}0185H_5 - 0{,}206R_m + 0{,}92T$$

$$r^2 = 0{,}80 \quad {**}$$

where

G = Individual animal mass gain (kg/animal/season) for the animal summer

S_5 = Stocking rate (LSU/ha) for the animal summer

V = Veld condition index (the sum of the proportions of <u>Themeda triandra</u> and <u>Tristachya leucothrix</u>)

H_5 = Residual herbage mass (kg/ha) at the end of the grass summer

R_m = Mean long-term rainfall (mm)

T = The length (weeks) of the animal summer (or the time over which animal mass gains occurred)

Initial mass, which was shown by Turner (1988) to be an important factor affecting IAP, was not an important factor affecting IAP in these analyses. Perhaps the reason for this lies in the inclusion of mean long-term rainfall, which would reflect perhaps the relative sweetness or sourness of a site (because generally veld becomes increasingly sour as rainfall increases). In the first season it was coincidence that the lighter animals were at Site 3 (which has the highest mean long-term rainfall and is therefore probably the sourest site) and the heavier animals at Site 4 and 5 (which have similar mean long-term rainfall but much lower than Site 3).

In the Lowveld the length of the animal summer was closely related to the distribution of summer rainfall. This was not the case for the Tall Grassveld. This could possibly be due to two factors. First, winter rain will provide a flush in the spring even though the spring rains are late. Second, there is a drop in quality of this veld in autumn, part of which is probably independent of rainfall. Fortunately, this factor was the least important factor in the model presented above (and the factor which in any case had a relatively very small effect on IAP). A model which does not include the length of the animal summer (or the time over which gains occurred) was therefore developed and is as follows:

$$G = 356{,}1 - 60S_5 - 0{,}37V - 0{,}0112H_5 - 0{,}194R_m$$

$$r^2 = 0{,}73 \quad **$$

where

G = Individual animal mass gain (kg/animal/season) for the animal summer

S_5 = Stocking rate (LSU/ha) for the animal summer

V = Veld condition index (the sum of the proportions of <u>Themeda</u> <u>triandra</u> and <u>Tristachya</u> <u>leucothrix</u>)

H_5 = Residual herbage mass (kg/ha) at the end of the grass summer

R_m = Mean long-term rainfall (mm)

It is interesting to note that in these two models veld condition index has a far greater negative effect on IAP in the second model (which has fewer factors). In stepwise regression analysis, veld condition was the most important factor affecting IAP, and had a much greater negative effect on IAP than in either of these two models. The linear regression model obtained was as follows:

$$G = 168{,}4 - 0{,}85V \qquad r^2 = 0{,}55 \quad **$$

where

G = Individual animal mass gain (kg/animal/season) for the animal summer

V = Veld condition index (the sum of the proportions of _Themeda triandra_ and _Tristachya leucothrix_)

Veld condition index probably reflects several parameters which have a major impact on animal performance. For example, veld in good condition has a higher production potential and therefore a higher grazing capacity. However, because veld in good condition grows more quickly, one would expect it to become mature sooner and therefore to have a higher fibre content. From the point of view of individual animal performance, it will be of poorer quality. This is probably what is largely reflected in the VCI in these models. In addition, in this instance it is perhaps coincidental that the poorest IAP performance was obtained on the site which was in the best condition. This site is probably also the most sour. Thus, when mean long-term rainfall was included in the model (the second most important factor in the stepwise regression) the coefficient for veld condition index dropped to 0,63 (r^2 = 0,65).

That the VCI is a complex parameter is borne out by the decrease in significance as each additional parameter was included in the stepwise modelling procedure. Indeed, when VCI was excluded as a parameter, the remaining parameters from the second model presented above accounted for almost the same variation in individual animal performance as was accounted for when VCI was included. The model which was developed is as follows:

$$G = 415{,}3 - 80{,}3S_s - 0{,}0179H_s - 0{,}253R_{\blacksquare}$$

$r^2 = 0{,}68$ **

where

G = Individual animal mass gain (kg/animal/season) for the animal summer

S_s = Stocking rate (LSU/ha) for the animal summer

H_s = Residual herbage mass (kg/ha) at the end of the grass summer

$R_{\blacksquare}$ = Mean long-term rainfall (mm)

Because the VCI is a parameter for predicting herbage mass, which is also used as an input for predicting animal performance, VCI and herbage mass are correlated. On this basis the latter model for predicting individual animal performance in the Tall Grassveld is the preferred model.

CHAPTER 11

A STOCKING RATE MODEL FOR THE TALL GRASSVELD

CHAPTER 11

A STOCKING RATE MODEL FOR THE TALL GRASSVELD

11.1 A DESCRIPTION OF THE STOCKING RATE MODEL FOR THE TALL GRASSVELD

The component models described in Chapters 9 and 10 were integrated to produce a stocking rate model for the Tall Grassveld, illustrated in Fig. 11.1. As for the Lowveld model, the following should be noted with respect to the layout of Fig. 11.1: some parameters (free standing) are essential for determining the direct inputs (in blocks with a single outline). The direct inputs are those required for obtaining output from the models (the positions of which are indicated by blocks which are shadowed). With the herbage mass models an additional step may be useful to determine the herbage available to the grazing animal (indicated by blocks

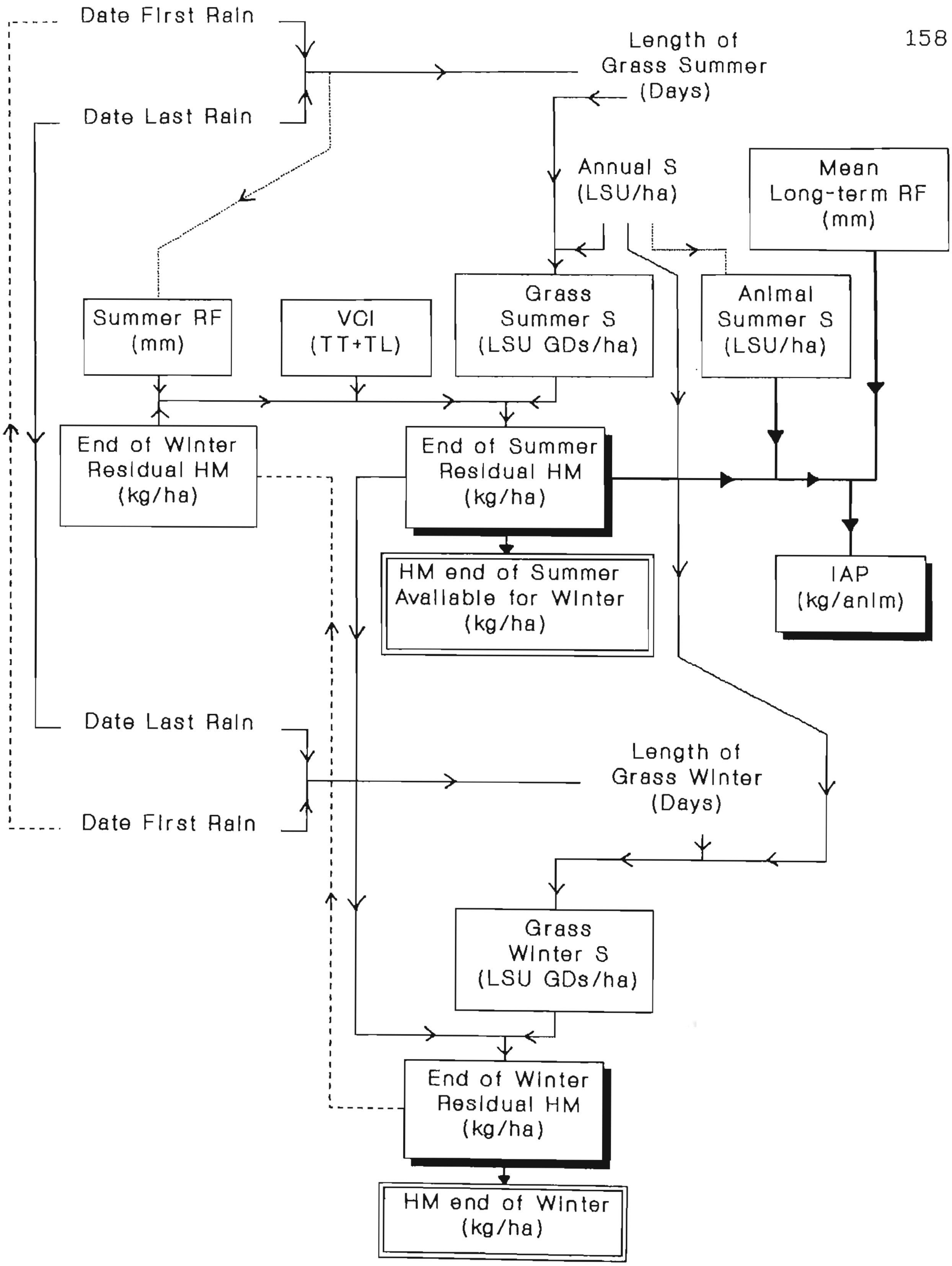


Fig. 11.1 A stocking rate model for the Tall Grassveld. The layout is fully explained in the text.

with a double outline). The thin solid lines indicate the flow of inputs to the herbage mass models. The thick solid lines indicate the flow of inputs to the animal performance model. The finely dotted lines indicate steps where the following parameter is indirectly calculated from the preceding parameter or requires some judgement. The stippled lines indicate the required flow of information for successive iterations of the model over successive seasons (with all other inputs remaining constant).

This model may be used in both for planning and for aiding in management decisions at farm level. The applications and the suggested approaches for the use of the model in each of these applications is discussed in greater detail in the conclusion.

11.2 PRACTICAL ASPECTS ON THE CALCULATION OF PARAMETERS

The calculation of the inputs has already been described in the development of the component models. For the same reasons as for the Lowveld, some guidelines for the calculation of the inputs at farm level may be useful.

a. <u>Length of the grass summer</u>. The date of the first summer rain (arbitrarily say > 15 mm, either in a single storm or dispersed over 2 or 3 days) will not be as easy to establish in the Tall Grassveld as it is in the Lowveld, particularly in seasons where late winter rain falls in August. At the end of the season, there appears to be little response in grass growth to rain which falls in April. In the development of the component models, the subjectively allocated transitions from the grass winter to the grass summer occurred around the beginning of September and around the end of March each year. Should there be no clear transition between winter and summer, then the 1st September would probably be a reasonable approximation of the time when grass growth starts in response to rainfall. However, if the start of the grass summer is obvious, as for example in the spring of 1989 when the first rains fell at the beginning of November, then the date of the first rain after the 1st September should be used as the date of first rains. In view of the low response in grass growth to rainfall in April, the 31st March is probably a reasonable approximation of the end of the grass summer.

b. Summer rainfall (mm). For practical purposes, the total rainfall occurring between 1st September and 31st March should accurately represent the summer rainfall. Note that length of the grass summer does not affect IAP. Also, the effects of rainfall are strongly modified by the VCI. Thus some inaccuracy here should not introduce a large error.

c. End of winter residual herbage mass (kg/ha). As with the Lowveld, it is suggested that a grazing cut-off of 4 cm be adopted (although it is recognised that this may differ with different sward conditions and for different defoliation regimes). Because of the relatively heavy stocking rates that are currently being applied in these areas, it is unlikely that there will be much residual herbage in excess of that available to animals at the end of the winter. In the absence of estimates of residual herbage mass at the end of winter using the disc meter, the following guidelines are suggested:

heavily grazed sward - 4 cm or 1868 kg/ha;
moderately grazed sward - 5 cm or 2253 kg/ha;
lightly grazed sward - 6 cm or 2639 kg/ha; and
if veld was burnt - 0 kg/ha.

Should these be underestimates, it will introduce conservatism into the model. Note that the output from the model for the previous winter could also be used as input into the model for the following summer. However, such iteration of the model from season to season without some verification will be unwise in the application of the model. From experience, it is suggested that the end of the winter would be the easiest time to do such an evaluation in preference to the end of summer.

d. Veld condition index (VCI). Only two species were used in the calculation of VCI. The same cautions suggested for the determination of the VCI for the Lowveld should be adopted for the determination of the VCI for the Tall Grassveld (see Section 7.2).

e. Grass summer stocking rate (S) (LSU GDs/ha) for the end of summer HM component model. This is calculated from the mean annual stocking rate (Annual S (LSU/ha)). For the farm situation, LSUE should be realistically assigned to various classes of stock using the guidelines of Meissner et al. (1983).

f. Animal summer stocking rate (S) (LSU/ha) for the IAP component model. The solution suggested for the Lowveld Model is recommended here: a guide may be obtained from the ratios of summer:mean stocking rate in Table 8.3. The following conversion factors for calculating summer stocking rate from mean annual stocking rate are suggested:

for a dry season (600-700 mm) - 1,2;
for a moderate season (700-800 mm) - 1,15; and
for a wet season (800+ mm) - 1,1.

Once again, the impact of stocking rate on animal performance over the range which would be applied in practice would be relatively small. Some inaccuracy here would therefore not introduce a large error in the result.

g. <u>End of summer residual herbage mass (kg/ha)</u>. It is suggested that the output from the summer component model be used as the input for this component model, particularly where the end of summer residual HM cannot be objectively determined.

h. <u>Grass winter stocking rate (S) (LSU GDs/ha)</u>. This is calculated in the same way as the summer stocking rate i.e. from the mean annual stocking rate (Annual S (LSU/ha)).

As for the Lowveld Model, the calculation of the available residual herbage mass at the end of each season is optional. The grazing cut-off suggested in Section 8.4 is 1868 kg/ha (a disc height of 4 cm). To obtain an estimate of available herbage, the estimated grazing cut-off is simply subtracted from the output of the herbage mass component models.

11.3 MODELLING STOCKING RATE FOR THE TALL GRASSVELD

A typical scenario for the Tall Grassveld is given in Table 11.1. This scenario forms the basis of the remaining discussion in this Section in which the effects of altering the stocking rate and the length of the winter for veld in different conditions and for differences in rainfall will be assessed. Some points therefore need to be noted. The

Table 11.1 A basic scenario for unburnt veld using the stocking rate model for the Tall Grassveld. A summer rainfall of 750 mm (used in the table) would be about 50 to 100 mm heavier than the mean summer rainfall for much of the Tall Grassveld.

Mean annual rainfall	(mm)	750
Mean annual S	(ha/LSU)	2.5
Mean annual S	(LSU/ha)	0.44
SUMMER GRASS PRODUCTION:		
First summer rain	(date)	1 Oct
Last summer rain	(date)	31 Mar
Length grass summer	(days)	181
Length grass summer	(weeks)	26
Grass summer S	(LSU GDs/ha)	72
HM (end of winter)	(kg/ha)	1868
RF (summer)	(mm)	750
VCI	(TT+TL)	50
HM (end of summer)	(kg/ha)	3614
DH (grazing cut-off)	(cm)	4
HM (grazing cut-off)	(kg/ha)	1868
HM (available for winter use)	(kg/ha)	1746
WINTER GRASS PRODUCTION:		
Last summer rain	(date)	31 Mar
First summer rain	(date)	01 Oct
Length grass winter	(days)	184
Length grass winter	(weeks)	26
Grass winter S	(LSU GDs/ha)	74
HM (end of summer)	(kg/ha)	3614
HM (end of winter)	(kg/ha)	3005
HM (grazing cut-off)	(kg/ha)	1868
HM (available at the end of winter)	(kg/ha)	1137

DH = Disc height
HM = Herbage mass
RF = Rainfall
S = Stocking rate
VCI = Veld condition index

stocking rate of 0,4 LSU/ha (or 2,5 ha/LSU) is probably light in comparison with currently applied stocking rates in farming situations in this area. This has, however, been used as a basis for an intermediate stocking rate because it is the stocking rate which the author feels would be "safe" under most environmental conditions in this area on moderately good veld (VCI 60+) and which would give a reasonable level of individual animal performance. In relation to the stocking rate selected as intermediate in the Lowveld, this stocking rate is probably more conservative. The dates for the first and last summer rains used in Table 11.1 are probably a fair reflection of a "normal" year for the Tall Grassveld Shulze, 1982). No residual carry over of available herbage (above the grazing cut-off) into the summer has been assumed. The HM values in the remaining tables will also be expressed as residual available herbage mass assuming a grazing cut-off of 1868 kg/ha or a disc height of 4 cm.

The result of altering veld condition and rainfall in the model, under conditions otherwise similar to those in the scenario presented in Table 11.1, are shown in Table 11.2. Under these conditions cattle could probably be overwintered without additional supplementary feed i.e. feed in excess of the normal licks that are required, even on very poor veld.

The decrease in ability to overwinter cattle when stocking rate is increased (to 0,67 LSU/ha or 1,5 ha/LSU), and the increase in ability when stocking rate is decreased (to 0,29

Table 11.2 Residual available herbage mass (HM), for unburnt veld, at the end of summer and at the end of the following winter and individual animal performance (IAP) for the summer for different levels of veld condition (VCI) and summer rainfall. All other conditions are the same as those in Table 11.1. A conversion factor of 1,15 was used to convert mean annual stocking rate to an animal summer stocking rate (see page 162).

Summer Rainfall (mm)	End of Summer Residual HM (kg/ha)				
	VCI				
	0	20	40	60	80
300	553	853	1153	1453	1753
400	651	951	1252	1552	1852
500	750	1050	1350	1650	1950
600	848	1148	1448	1748	2049
700	946	1246	1547	1847	2147
800	1045	1345	1645	1945	2245
900	1143	1443	1743	2043	2344
1000	1241	1542	1842	2142	2442
	End of Winter Residual HM (kg/ha)				
300	201	436	672	907	1143
400	278	513	749	985	1220
500	355	591	826	1062	1297
600	432	668	903	1139	1375
700	509	745	981	1216	1452
800	587	822	1058	1294	1529
900	664	899	1135	1371	1606
1000	741	977	1212	1448	1684
	Summer IAP (kg/summer)				
300	145	140	134	129	124
400	143	138	133	127	122
500	142	136	131	126	120
600	140	135	129	124	118
700	138	133	127	122	117
800	136	131	126	120	115
900	135	129	124	119	113
1000	133	127	122	117	111

LSU/ha or 3,5 ha/LSU) under conditions otherwise similar to those shown in Table 11.2, is shown in Tables 11.3 and 11.4 respectively. In Table 11.3 it is shown that the heavier stocking rate has a marked influence on the ability to overwinter cattle without having additional supplementary feed. A VCI of at least 20 would be required to comfortably overwinter cattle after a normal year (about 650 mm mean summer rainfall). Cattle could be overwintered without additional supplementary feed in dry years (<600 mm) only on veld in at least moderate condition (VCI > 40). Note that at this heavy stocking rate individual animal performance in the summer also decreases markedly. In Table 11.4 it is shown that, at the lighter stocking rate, there would be little trouble in overwintering cattle on veld, even on veld in very poor condition. It should be noted that the lowest animal performance that could be expected under these environmental conditions at the light stocking rate is close to the maximum that could be expected under the same environmental conditions at the heavy stocking rate.

For the same reasons as for the Lowveld, it is not unreasonable to suggest that there should be sufficient veld to carry animals at least until the middle of November without having to supply additional supplementary feed. The effect of a late spring (1st summer rains occurring on 15th November), under conditions otherwise similar to those in Table 11.1 but at the different stocking rates (the same as those in Tables 11.2, 11.3 and 11.4), are shown in Tables 11.5, 11.6 and 11.7.

Table 11.3 Residual available herbage mass (HM), for unburnt veld, at the end of summer and at the end of the following winter and individual animal performance (IAP) for the summer for different levels of veld condition (VCI) and summer rainfall. All other conditions are the same as those in Table 11.2 except stocking rate which is heavier (0,67 LSU/ha or 1,5 ha/LSU). A conversion factor of 1,15 was used to convert mean annual stocking rate to an animal summer stocking rate (see page 162).

Summer Rainfall (mm)	End of Summer Residual HM (kg/ha)				
	VCI				
	0	20	40	60	80
300	105	405	705	1005	1305
400	203	503	803	1104	1404
500	301	602	902	1202	1502
600	400	700	1000	1300	1600
700	498	798	1098	1399	1699
800	597	897	1197	1497	1797
900	695	995	1295	1595	1895
1000	793	1093	1394	1694	1994
	End of Winter Residual HM (kg/ha)				
300	0	0	45	281	516
400	0	0	122	358	593
500	0	0	199	435	671
600	0	41	277	512	748
700	0	118	354	589	825
800	0	195	431	667	902
900	37	273	508	744	979
1000	114	350	585	821	1057
	Summer IAP (kg/summer)				
300	129	123	118	112	107
400	127	121	116	111	105
500	125	120	114	109	104
600	123	118	113	107	102
700	122	116	111	105	100
800	120	114	109	104	98
900	118	113	107	102	97
1000	116	111	106	100	95

Table 11.4 Residual available herbage mass (HM), for unburnt veld, at the end of summer and at the end of the following winter and individual animal performance (IAP) for the summer for different levels of veld condition (VCI) and summer rainfall. All other conditions are the same as those in Table 11.2 except stocking rate which is lighter (0,29 LSU/ha or 3,5 ha/LSU). A conversion factor of 1,15 was used to convert mean annual stocking rate to an animal summer stocking rate (see page 162).

Summer Rainfall (mm)	End of Summer Residual HM (kg/ha)				
	VCI				
	0	20	40	60	80
300	745	1045	1345	1645	1945
400	843	1143	1444	1744	2044
500	942	1242	1542	1842	2142
600	1040	1340	1640	1940	2241
700	1138	1438	1739	2039	2339
800	1237	1537	1837	2137	2437
900	1335	1635	1935	2235	2536
1000	1433	1734	2034	2334	2634
	End of Winter Residual HM (kg/ha)				
300	469	705	941	1176	1412
400	546	782	1018	1253	1489
500	624	859	1095	1331	1566
600	701	937	1172	1408	1643
700	778	1014	1249	1485	1721
800	855	1091	1327	1562	1798
900	933	1168	1404	1639	1875
1000	1010	1245	1481	1717	1952
	Summer IAP (kg/summer)				
300	152	147	142	136	131
400	151	145	140	134	129
500	149	143	138	133	127
600	147	142	136	131	126
700	145	140	135	129	124
800	144	138	133	127	122
900	142	136	131	126	120
1000	140	135	129	124	118

Table 11.5 Residual available herbage mass (HM), for unburnt veld, at the end of summer and at the end of the following winter and individual animal performance (IAP) for the summer for different levels of veld condition (VCI) and summer rainfall. All other conditions are the same as those in Table 11.2 except the date of the first summer rain at the end of the winter which has been delayed to 15 November. A conversion factor of 1,15 was used to convert mean annual stocking rate to an animal summer stocking rate (see page 162).

Summer Rainfall (mm)	End of Summer Residual HM (kg/ha)				
	VCI				
	0	20	40	60	80
300	553	853	1153	1453	1753
400	651	951	1252	1552	1852
500	750	1050	1350	1650	1950
600	848	1148	1448	1748	2049
700	946	1246	1547	1847	2147
800	1045	1345	1645	1945	2245
900	1143	1443	1743	2043	2344
1000	1241	1542	1842	2142	2442
	End of Winter Residual HM (kg/ha)				
300	100	335	571	807	1042
400	177	413	648	884	1119
500	254	490	725	961	1197
600	331	567	803	1038	1274
700	409	644	880	1115	1351
800	486	721	957	1193	1428
900	563	799	1034	1270	1505
1000	640	876	1111	1347	1583
	Summer IAP (kg/summer)				
300	145	140	134	129	124
400	143	138	133	127	122
500	142	136	131	126	120
600	140	135	129	124	118
700	138	133	127	122	117
800	136	131	126	120	115
900	135	129	124	119	113
1000	133	127	122	117	111

Table 11.6 Residual available herbage mass (HM), for unburnt veld, at the end of summer and at the end of the following winter and individual animal performance (IAP) for the summer for different levels of veld condition (VCI) and summer rainfall. All other conditions are the same as those in Table 11.2 except the date of the first summer rain at the end of the winter which has been delayed to 15 November and stocking rate which is heavier (0,67 LSU/ha or 1,5 ha/LSU). A conversion factor of 1,15 was used to convert mean annual stocking rate to an animal summer stocking rate (see page 162).

Summer Rainfall (mm)	End of Summer Residual HM (kg/ha)				
	VCI				
	0	20	40	60	80
300	105	405	705	1005	1305
400	203	503	803	1104	1404
500	301	602	902	1202	1502
600	400	700	1000	1300	1600
700	498	798	1098	1399	1699
800	597	897	1197	1497	1797
900	695	995	1295	1595	1895
1000	793	1093	1394	1694	1994
	End of Winter Residual HM (kg/ha)				
300	0	0	0	112	348
400	0	0	0	190	425
500	0	0	31	267	502
600	0	0	108	344	580
700	0	0	186	421	657
800	0	27	263	498	734
900	0	104	340	576	811
1000	0	182	417	653	889
	Summer IAP (kg/summer)				
300	129	123	118	112	107
400	127	121	116	111	105
500	125	120	114	109	104
600	123	118	113	107	102
700	122	116	111	105	100
800	120	114	109	104	98
900	118	113	107	102	97
1000	116	111	106	100	95

Table 11.7 Residual available herbage mass (HM), for unburnt veld, at the end of summer and at the end of the following winter and individual animal performance (IAP) for the summer for different levels of veld condition (VCI) and summer rainfall. All other conditions are the same as those in Table 11.2 except the date of the first summer rain at the end of the winter which has been delayed to 15 November and stocking rate which is lighter (0,29 LSU/ha or 3,5 ha/LSU). A conversion factor of 1,15 was used to convert mean annual stocking rate to an animal summer stocking rate (see page 162).

Summer Rainfall (mm)	End of Summer Residual HM (kg/ha)				
	VCI				
	0	20	40	60	80
300	745	1045	1345	1645	1945
400	843	1143	1444	1744	2044
500	942	1242	1542	1842	2142
600	1040	1340	1640	1940	2241
700	1138	1438	1739	2039	2339
800	1237	1537	1837	2137	2437
900	1335	1635	1935	2235	2536
1000	1433	1734	2034	2334	2634
	End of Winter Residual HM (kg/ha)				
300	397	633	868	1104	1340
400	474	710	946	1181	1417
500	552	787	1023	1258	1494
600	629	864	1100	1336	1571
700	706	942	1177	1413	1648
800	783	1019	1254	1490	1726
900	860	1096	1332	1567	1803
1000	938	1173	1409	1644	1880
	Summer IAP (kg/summer)				
300	152	147	142	136	131
400	151	145	140	134	129
500	149	143	138	133	127
600	147	142	136	131	126
700	145	140	135	129	124
800	144	138	133	127	122
900	142	136	131	126	120
1000	140	135	129	124	118

At the intermediate stocking rate (Table 11.5) cattle would comfortably overwinter under most conditions except, perhaps, for very dry years on veld in poor condition (Table 11.5 and 11.6). At the heavy stocking rate (Table 11.6) it would be possible to overwinter cattle without additional supplementary feed after dry years only on veld in good condition (VCI > 60). On veld in moderate condition (VCI = 40) cattle could be overwintered without additional supplementary feed only after a reasonable year (> 600 mm). On veld in moderate to poor condition (VCI < 40) supplementary feeding would be necessary in the winter if the spring rains were late, irrespective of the conditions during the preceding summer.

Animal performance in Tables 11.2, 11.3 and 11.4 is the same as in Tables 11.5, 11.6 and 11.7 respectively. The reason is that late rains in spring do not affect the conditions in the preceding summer. The same constraint applies to the use of the IAP component model for the Tall Grassveld as applies to the IAP component model for the Lowveld viz. that it will be valid only when forage availability is not limiting to animal performance.

Animal performance during the winter would be dependent on the supplementary feeding strategy adopted for each particular group of animals. These trials were not designed to determine the possible effect of stocking rate on the supplementary feed required in winter. Only the relative performance of animals under a similar feeding strategy could be established. This is, however, of little consequence in the context of modelling stocking rate in this veld type, in which the influence of stocking rate on winter animal performance will really only become critical when there is a limitation in available forage.

In Table 11.8 a scenario is presented which is similar to that presented in Table 11.1 except that the residual herbage carried over from the preceding winter is zero i.e. a scenario for burnt veld. In Tables 11.9 to 11.14 the effects of burning on residual available herbage and IAP for conditions otherwise similar to those in Tables 11.2 to 11.7 are shown. The overall effects of burning for any particular combination of stocking rate and environmental conditions are 1) to lower the probability of being able to overwinter cattle without additional supplementary feeding and 2) to increase the individual animal performance (about 8 kg/animal/season). This indicates that where some conservatism in stocking rate is introduced, loss in production from greater numbers could be partially compensated for by an increase in IAP through an increase in burning frequency.

Table 11.8 A basic scenario, following a spring burn, using the stocking rate model for the Tall Grassveld. The inputs are the same as in Table 11.1 except that the end of the preceeding winter residual carry over is 0 kg/ha i.e. burnt veld.

Mean annual rainfall	(mm)	750
Mean annual S	(ha/LSU)	2.5
Mean annual S	(LSU/ha)	0.44
SUMMER GRASS PRODUCTION:		
First summer rain	(date)	1 Oct
Last summer rain	(date)	31 Mar
Length grass summer	(days)	181
Length grass summer	(weeks)	26
Grass summer S	(LSU GDs/ha)	72
HM (end of winter)	(kg/ha)	0
RF (summer)	(mm)	750
VCI	(TT+TL)	50
HM (end of summer)	(kg/ha)	3209
DH (grazing cut-off)	(cm)	4
HM (grazing cut-off)	(kg/ha)	1868
HM (available for winter use)	(kg/ha)	1341
WINTER GRASS PRODUCTION:		
Last Summer Rain	(date)	31 Mar
First Summer Rain	(date)	01 Oct
Length grass winter	(days)	184
Length grass winter	(weeks)	26
Grass winter S	(LSU GDs/ha)	74
HM (end of summer)	(kg/ha)	3209
HM (end of winter)	(kg/ha)	2687
HM Grazing cut-off	(kg/ha)	1868
HM (available)	(kg/ha)	819

DH = Disc height
HM = Herbage mass
RF = Rainfall
S = Stocking rate
VCI = Veld condition index

Table 11.9 Residual available herbage mass (HM), following a spring burn, at the end of summer and at the end of the following winter and individual animal performance (IAP) for the summer for different levels of veld condition (VCI) and summer rainfall. All other conditions are <u>the same as those in Table 11.8</u>. A conversion factor of 1,15 was used to convert mean annual stocking rate to an animal summer stocking rate (see page 162).

Summer Rainfall (mm)	End of Summer Residual HM (kg/ha)				
	VCI				
	0	20	40	60	80
300	148	448	748	1048	1348
400	246	546	847	1147	1447
500	345	645	945	1245	1545
600	443	743	1043	1343	1644
700	541	841	1142	1442	1742
800	640	940	1240	1540	1840
900	738	1038	1338	1638	1939
1000	836	1137	1437	1737	2037
	End of Winter Residual HM (kg/ha)				
300	0	118	354	590	825
400	0	196	431	667	902
500	37	273	508	744	980
600	114	350	586	821	1057
700	192	427	663	898	1134
800	269	504	740	976	1211
900	346	582	817	1053	1288
1000	423	659	894	1130	1366
	Summer IAP (kg/summer)				
300	152	147	142	136	131
400	151	145	140	135	129
500	149	144	138	133	127
600	147	142	136	131	126
700	145	140	135	129	124
800	144	138	133	128	122
900	142	137	131	126	120
1000	140	135	129	124	119

Table 11.10 Residual available herbage mass (HM), following a spring burn, at the end of summer and at the end of the following winter and individual animal performance (IAP) for the summer for different levels of veld condition (VCI) and summer rainfall. All other conditions are the same as those in Table 11.9 except stocking rate which is heavier (0,67 LSU/ha or 1,5 ha/LSU). A conversion factor of 1,15 was used to convert mean annual stocking rate to an animal summer stocking rate (see page 162). ? = uncertain summer IAP due to a limit on herbage availability.

Summer Rainfall (mm)	End of Summer Residual HM (kg/ha)				
	VCI				
	0	20	40	60	80
300	0	0	300	600	900
400	0	98	398	699	999
500	0	197	497	797	1097
600	0	295	595	895	1195
700	93	393	693	994	1294
800	192	492	792	1092	1392
900	290	590	890	1190	1490
1000	388	688	989	1289	1589
	End of Winter Residual HM (kg/ha)				
300	0	0	0	0	198
400	0	0	0	40	276
500	0	0	0	117	353
600	0	0	0	194	430
700	0	0	36	272	507
800	0	0	113	349	584
900	0	0	190	426	662
1000	0	32	268	503	739
	Summer IAP (kg/summer)				
300	?	?	125	120	114
400	?	129	123	118	113
500	?	127	122	116	111
600	?	125	120	114	109
700	129	123	118	113	107
800	127	122	116	111	106
900	125	120	115	109	104
1000	124	118	113	107	102

Table 11.11 Residual available herbage mass (HM), following a spring burn, at the end of summer and at the end of the following winter and individual animal performance (IAP) for the summer for different levels of veld condition (VCI) and summer rainfall. All other conditions are the same as those in Table 11.9 except stocking rate which is lighter (0,29 LSU/ha or 3,5 ha/LSU). A conversion factor of 1,15 was used to convert mean annual stocking rate to an animal summer stocking rate (see page 162).

Summer Rainfall (mm)	End of Summer Residual HM (kg/ha)				
	VCI				
	0	20	40	60	80
300	340	640	940	1240	1541
400	438	738	1039	1339	1639
500	537	837	1137	1437	1737
600	635	935	1235	1535	1836
700	733	1034	1334	1634	1934
800	832	1132	1432	1732	2032
900	930	1230	1530	1831	2131
1000	1028	1329	1629	1929	2229
	End of Winter Residual HM (kg/ha)				
300	151	387	623	858	1094
400	229	464	700	935	1171
500	306	541	777	1013	1248
600	383	619	854	1090	1325
700	460	696	931	1167	1403
800	537	773	1009	1244	1480
900	615	850	1086	1321	1557
1000	692	927	1163	1399	1634
	Summer IAP (kg/summer)				
300	160	154	149	143	138
400	158	152	147	142	136
500	156	151	145	140	135
600	154	149	144	138	133
700	153	147	142	136	131
800	151	145	140	135	129
900	149	144	138	133	127
1000	147	142	136	131	126

Table 11.12 Residual available herbage mass (HM), following a spring burn, at the end of summer and at the end of the following winter and individual animal performance (IAP) for the summer for different levels of veld condition (VCI) and summer rainfall. All other conditions are the same as those in Table 11.9 except the date of the first summer rain at the end of the winter which has been delayed to 15 November. A conversion factor of 1,15 was used to convert mean annual stocking rate to an animal summer stocking rate (see page 162). ? = uncertain summer IAP due to a limit on herbage availability.

Summer Rainfall (mm)	End of Summer Residual HM (kg/ha)				
	VCI				
	0	20	40	60	80
300	148	448	748	1048	1348
400	246	546	847	1147	1447
500	345	645	945	1245	1545
600	443	743	1043	1343	1644
700	541	841	1142	1442	1742
800	640	940	1240	1540	1840
900	738	1038	1338	1638	1939
1000	836	1137	1437	1737	2037
	End of Winter Residual HM (kg/ha)				
300	0	17	253	489	724
400	0	95	330	566	801
500	0	172	407	643	879
600	13	249	485	720	956
700	91	326	562	797	1033
800	168	403	639	875	1110
900	245	481	716	952	1188
1000	322	558	793	1029	1265
	Summer IAP (kg/summer)				
300	152	147	142	136	131
400	151	145	140	135	129
500	149	144	138	133	127
600	147	142	136	131	126
700	145	140	135	129	124
800	144	138	133	128	122
900	142	137	131	126	120
1000	140	135	129	124	119

Table 11.13 Residual available herbage mass (HM), following a spring burn, at the end of summer and at the end of the following winter and individual animal performance (IAP) for the summer for different levels of veld condition (VCI) and summer rainfall. All other conditions are the same as those in Table 11.9 except the date of the first summer rain at the end of the winter which has been delayed to 15 November and stocking rate which is heavier (0,67 LSU/ha or 1,5 ha/LSU). A conversion factor of 1,15 was used to convert mean annual stocking rate to an animal summer stocking rate (see page 162).

Summer Rainfall (mm)	End of Summer Residual HM (kg/ha)				
	VCI				
	0	20	40	60	80
300	0	0	300	600	900
400	0	98	398	699	999
500	0	197	497	797	1097
600	0	295	595	895	1195
700	93	393	693	994	1294
800	192	492	792	1092	1392
900	290	590	890	1190	1490
1000	388	688	989	1289	1589
	End of Winter Residual HM (kg/ha)				
300	0	0	0	0	30
400	0	0	0	0	107
500	0	0	0	0	185
600	0	0	0	26	262
700	0	0	0	103	339
800	0	0	0	181	416
900	0	0	22	258	493
1000	0	0	99	335	571
	Summer IAP (kg/summer)				
300	?	?	125	120	114
400	?	129	123	118	113
500	?	127	122	116	111
600	?	125	120	114	109
700	129	123	118	113	107
800	127	122	116	111	106
900	125	120	115	109	104
1000	124	118	113	107	102

Table 11.14 Residual available herbage mass (HM), following a spring burn, at the end of summer and at the end of the following winter and individual animal performance (IAP) for the summer for different levels of veld condition (VCI) and summer rainfall. All other conditions are the same as those in Table 11.9 except the date of the first summer rain at the end of the winter which has been delayed to 15 November and stocking rate which is lighter (0,29 LSU/ha or 3,5 ha/LSU). A conversion factor of 1,15 was used to convert mean annual stocking rate to an animal summer stocking rate (see page 162).

Summer Rainfall (mm)	End of Summer Residual HM (kg/ha)				
	VCI				
	0	20	40	60	80
300	340	640	940	1240	1541
400	438	738	1039	1339	1639
500	537	837	1137	1437	1737
600	635	935	1235	1535	1836
700	733	1034	1334	1634	1934
800	832	1132	1432	1732	2032
900	930	1230	1530	1831	2131
1000	1028	1329	1629	1929	2229
	End of Winter Residual HM (kg/ha)				
300	79	315	551	786	1022
400	157	392	628	863	1099
500	234	469	705	941	1176
600	311	547	782	1018	1253
700	388	624	859	1095	1331
800	465	701	937	1172	1408
900	543	778	1014	1249	1485
1000	620	855	1091	1327	1562
	Summer IAP (kg/summer)				
300	160	154	149	143	138
400	158	152	147	142	136
500	156	151	145	140	135
600	154	149	144	138	133
700	153	147	142	136	131
800	151	145	140	135	129
900	149	144	138	133	127
1000	147	142	136	131	126

PART 4

THE DEVELOPMENT OF A STOCKING RATE MODEL FOR THE SOUR SANDVELD

CHAPTER

PART 4

OVERVIEW

The Sour Sandveld lies in northern Natal. It covers an area of approximately 5 463 km^2 (6,2%) of Natal (Edwards, 1974). The topography is fairly flat. Dolerite ridges and hills are scattered throughout the area but these are usually outliers of Tall Grassveld. However, they do in places appear to be transitional between Tall Grassveld and Sour Sandveld.

The mean annual rainfall varies from less than 700 mm to over 800 mm (Shulze, 1982). The seasonal variation in rainfall is also large. The rain falls mainly in the summer months. However, winter falls of rain usually occur in July and August.

Frost occurs in winter. Winters are therefore cold. This puts a restriction on grass growth during this period.

The Sour Sandveld is also a fire climax grassland. Acacia sieberana sometimes occurs but it also tends to be associated with the dolerite outcrops. Distinct grass communities may often be identified, influenced to a large extent by soils and topography. For example where the soils are seasonally waterlogged (which is a common feature of bottomlands) the sward will be dominated by Andropogon eucomis and Imperata cylindrica. Old lands are also plentiful in this veld type. In bottomland situations they are typically dominated by a mixture of Andropogon eucomis and Cynodon dactylon. When they are not in a bottomland situation, they are typically dominated by a mixture of Hyparrhenia hirta and Cynodon dactylon.

Of the three veld types under study, the Sour Sandveld had the highest grass species diversity. In veld considered to be in good condition, the grass sward is dominated by Themeda triandra, although it does not occur in the same abundance as in the Tall Grassveld. Elionurus muticus is generally common in the sward of this veld type. Degraded veld is typically dominated by a large variety of unacceptable grasses, the most abundant of which are Eragrostis plana and Elionurus muticus. Other unacceptable grasses which may occur in degraded veld are Trachypogon spicatus, Loudetia simplex, Eragrostis curvula and E. gummiflua.

Farming in this veld type is also typically mixed and the main agricultural products (as for the Tall Grassveld) are beef, mutton (with some income from wool), milk (usually produced in intensive systems), maize, wheat and some grain sorghum. More emphasis is perhaps placed on sheep than in the Tall Grassveld. Beef production is, however, still often the most important farming enterprise in these areas.

Cattle are run on the veld all year. Use is generally made of licks. During the summer animals are usually supplemented with mineral licks and during the winter with rumen stimulating licks. Hay is usually produced as a winter feed and as a fodder reserve from both veld and from cultivated pastures. Because of the generally poor quality of the veld in this veld type, more emphasis is placed on the provision of winter feed, for example, hay, pastures and crop residues, than in the Tall Grassveld. Veld, however, remains the basis for livestock production. Here also the primary objectives for veld management should be 1) to ensure a good productive sward and 2) to ensure that there is sufficient grass to run animals on veld throughout the year without having to purchase supplementary feed. However, in view of the poorer quality of the veld and the greater emphasis on the production of alternative sources of food for overwintering animals, the latter objective is generally of much less importance.

Pastures are being increasingly established, particularly on land which is marginal for maize production. Summer pastures often encountered are *Cynodon* species (particularly Coastcross 2), *Eragrostis curvula* (primarily for hay) and *Digitaria eriantha*. Winter pastures are also widely grown, particularly *Lolium multiflorum* (ryegrass) under irrigation.

Fire is also an important management tool in these areas. Because of the large proportion of unacceptable species, it is doubtful whether an acceptable level of sustained animal production would be achieved from veld where fire was not used fairly regularly.

CHAPTER 12

RESULTS AND DISCUSSION

CHAPTER 12

RESULTS AND DISCUSSION

12.1 RAINFALL

Monthly rainfall over the three seasons for Sites 6 and 7 is shown in Figs 12.1 and 12.2. Also indicated is the expected distribution of rainfall (Shulze, 1982) for the amount received in each particular season. The annual rainfall (mm) over the three years for the two sites situated in the Sour Sandveld is shown in Table 12.1.

There was generally a progressive increase in rainfall at these sites over the three seasons. Except for season one at Site 7, rainfall was above the estimated long-term mean in all three seasons. Rainfall was on average much higher at Site 6

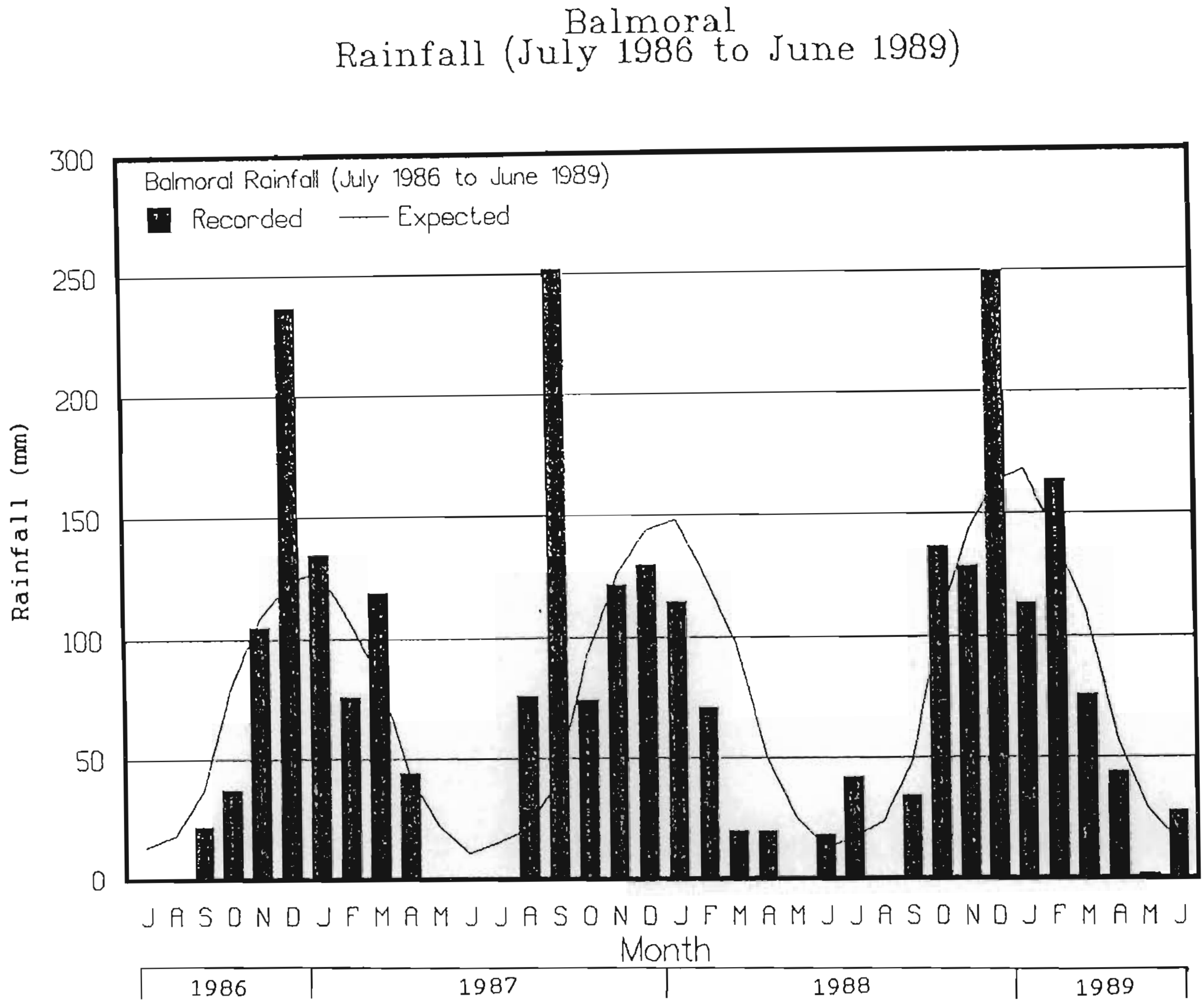


Fig. 12.1. Monthly rainfall at Site 6 over the three year experimental period. The solid line indicates the expected distribution of rainfall over the three years, based on mean long-term percentage distribution for each month.

Gowan Brae
Rainfall (July 1986 to June 1989)

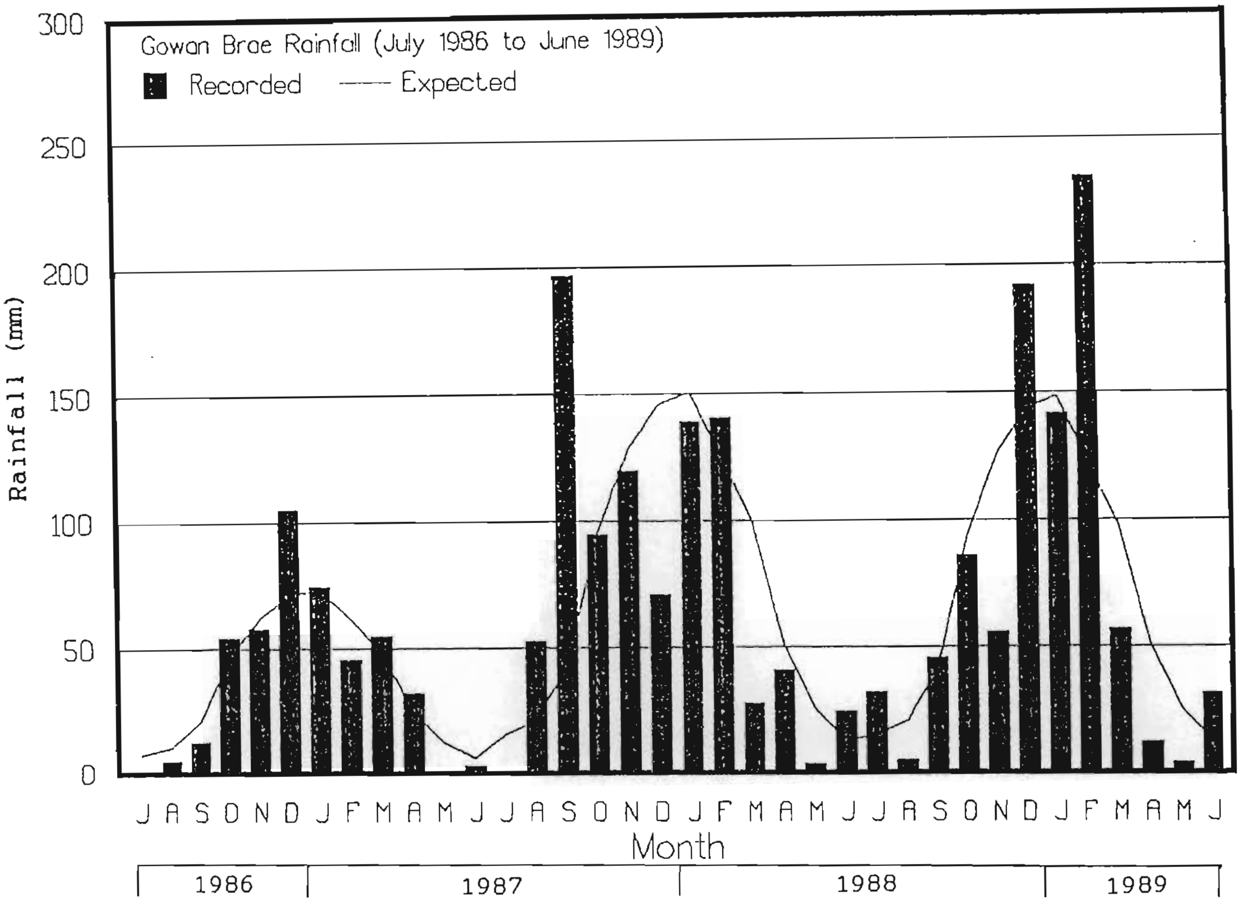


Fig. 12.2. Monthly rainfall at Site 7 over the three year experimental period. The solid line indicates the expected distribution of rainfall over the three years, based on mean long-term percentage distribution for each month.

Table 12.1. Seasonal and average rainfall over the three year trial period and mean long-term rainfall for Sites 6 and 7.

Season	Rainfall (mm)	
	Site 6	Site 7
1986/87	775	446
1987/88	898	913
1988/89	1020	899
mean	898	752
mean long-term	696	711

than at Site 7 over the three seasons, attributable largely to the difference in the first season.

12.2 VELD CONDITION

Proportional species composition data collected in January 1987 were used to develop indices of veld condition. It was assumed that there was no change in veld condition over the three seasons under analysis. As indicated for the Lowveld, this may not be entirely correct. The utilisation has been relatively heavy despite the generally good rainfall that has occurred. Thus the effects of stocking rate at the rates which were applied were relatively much greater than had been anticipated.

Assessment of these data indicated that only nine grass species occurred with an abundance of over 5% in any particular camp (Table 12.2). These species are *Themeda triandra*, *Tristachya leucothrix*, *Heteropogon contortus*, *Hyparrhenia hirta*, *Digitaria tricholaenoides*, *Eragrostis capensis*, *E. plana*, *E. curvula* and *Elionurus muticus*. At Site 6 they made up 75% and at Site 7 they made up 61% of the total proportional species composition. Individually, therefore, other species would have contributed relatively little to herbage production. Although the proportional composition of these species at Site 7 is low, this site had the largest diversity of species (43 species).

Table 12.2. The proportional species composition of the nine grass species which made up at least 5% of the proportional species composition in any single camp at Sites 6 and 7. (L, M and H are the light, moderate and heavy stocking rate treatments respectively and m = mean.)

Site, Treatment & camp	Proportional species composition (%)								
	TTR	TLE	HCO	HHI	DTR	ECA	EPL	ECU	EMU
L1	33	2	7	6	1	5	8	11	5
L2	8	2	11	3	4	6	16	3	22
L3	16	1	12	3	3	5	11	12	12
L4	7	1	11	7	1	5	23	12	10
mL	16	1	10	5	2	5	14	9	12
M1	24	3	6	11	2	4	7	3	9
M2	34	1	13	6	0	5	4	10	8
M3	14	0	10	14	0	9	4	5	16
M4	17	1	9	5	2	7	21	6	5
mM	22	2	9	9	1	6	9	6	10
H1	15	2	9	4	0	7	7	11	16
H2	17	0	14	10	0	8	5	2	15
H3	18	1	13	9	0	8	6	5	21
H4	13	5	16	2	1	8	3	10	19
mH	16	2	13	6	0	8	5	7	18
m(Site 6)	18	2	11	7	1	6	10	7	13
L1	0	6	3	3	9	2	2	6	10
L2	9	5	17	4	11	6	0	5	10
L3	23	5	11	2	0	8	12	3	5
L4	12	4	11	11	7	6	2	6	5
mL	11	5	10	5	7	5	4	5	8
M1	2	5	4	5	14	5	0	2	17
M2	1	3	7	1	27	3	1	2	11
M3	2	1	3	13	15	8	2	11	7
M4	26	27	6	2	1	3	4	3	4
mM	8	9	5	5	14	5	2	5	10
H1	4	5	9	6	19	3	0	1	11
H2	2	4	11	5	18	5	0	2	14
H3	8	10	6	5	1	5	12	6	12
H4	10	20	8	6	6	3	1	2	6
mH	6	10	9	6	11	4	3	3	11
m(Site 7)	8	8	8	5	11	5	3	4	9

TTR = *Themeda triandra*
TLE = *Tristachya leucothrix*
HCO = *Heteropogon contortus*
HHI = *Hyparrhenia hirta*
DTR = *Digitaria tricholaenoides*
ECA = *Eragrostis capensis*
EPL = *E. plana*
ECU = *E. curvula*
EMU = *Elionurus muticus*

From Table 12.2 it is clear that these sites were not very homogeneous. In particular, at Site 7 the camps of groups 1 and 2 are quite different from those of groups 3 and 4.

12.3 CHANGES IN DISC HEIGHT AND HERBAGE MASS

The changes in DH for each camp are presented in Figs 12.3 and 12.4 for Sites 6 and 7 respectively. Data were collected every three weeks. The first data (period 0) were collected on 24 November 1986 and the last data (period 45) on the 28 June 1989. Also indicated in these figures are 1) the rainfall which occurred during every period and 2) whether or not camps were grazed during the period. DM readings relate to each measuring time (which were three weeks apart) but rainfall and grazing relate to the interval between measuring time prior to the time indicated. It should also be noted that the figures are not arranged in the order that groups of camps at a particular site are numbered. For convenience of comparison, they are arranged so that groups of camps which received comparable treatments at the different sites in a particular season are in the same order (as explained in Section 8.3).

The times at which camps were burnt is again evident from the large decreases which are shown to have suddenly occurred. It should be noted here also that because all the camps were

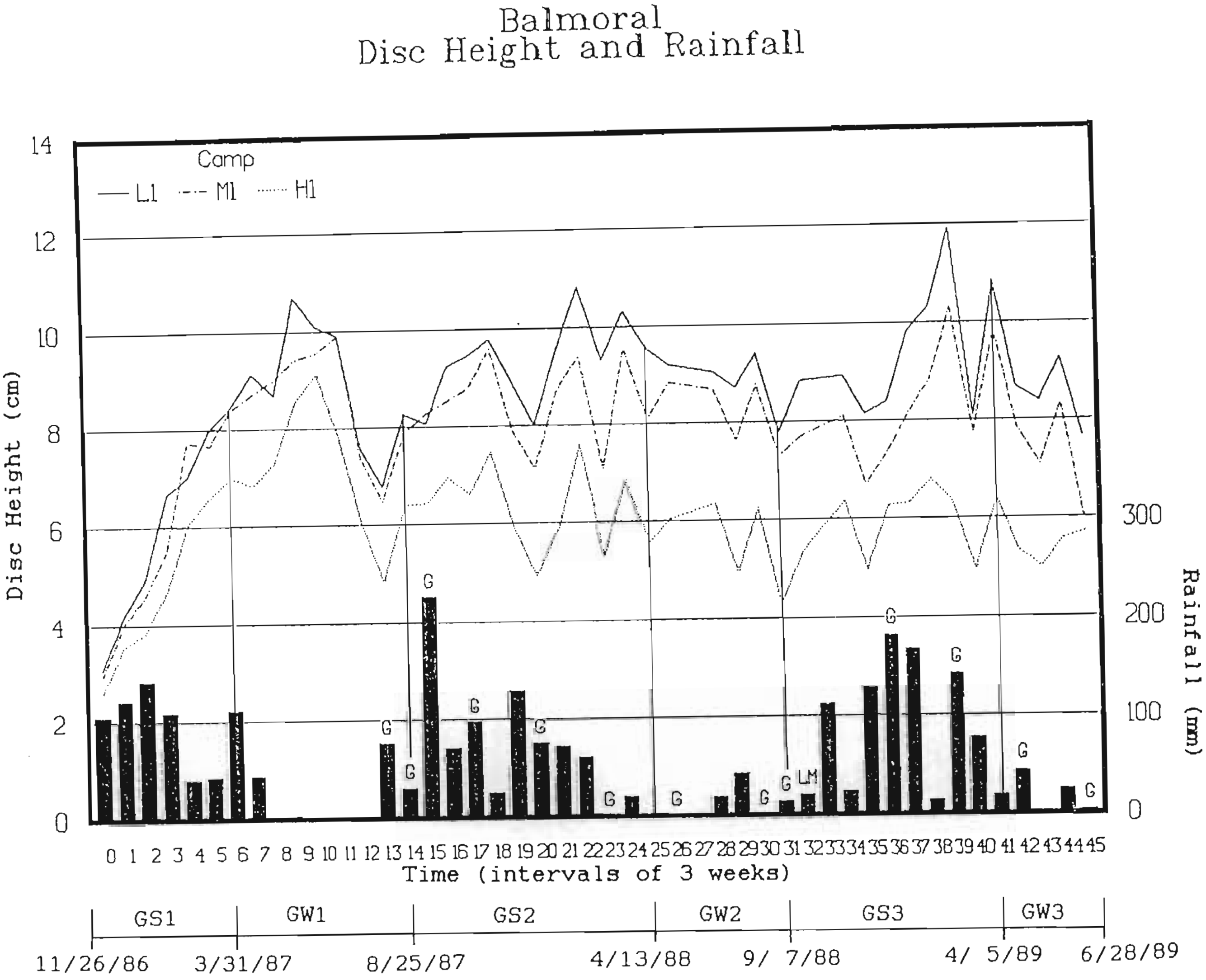


Fig. 12.3a. Disc height (cm) at each measuring period for each camp of group 1 at Site 6. Also indicated is the rainfall (mm) that occurred during each period and the periods during which each camp in the group was grazed (G = whole group; where the whole group was not grazed the camps from the respective treatments are indicated). The vertical lines show the grass summers (GS) and grass winters (GW) (which are labelled below the X-axis). (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

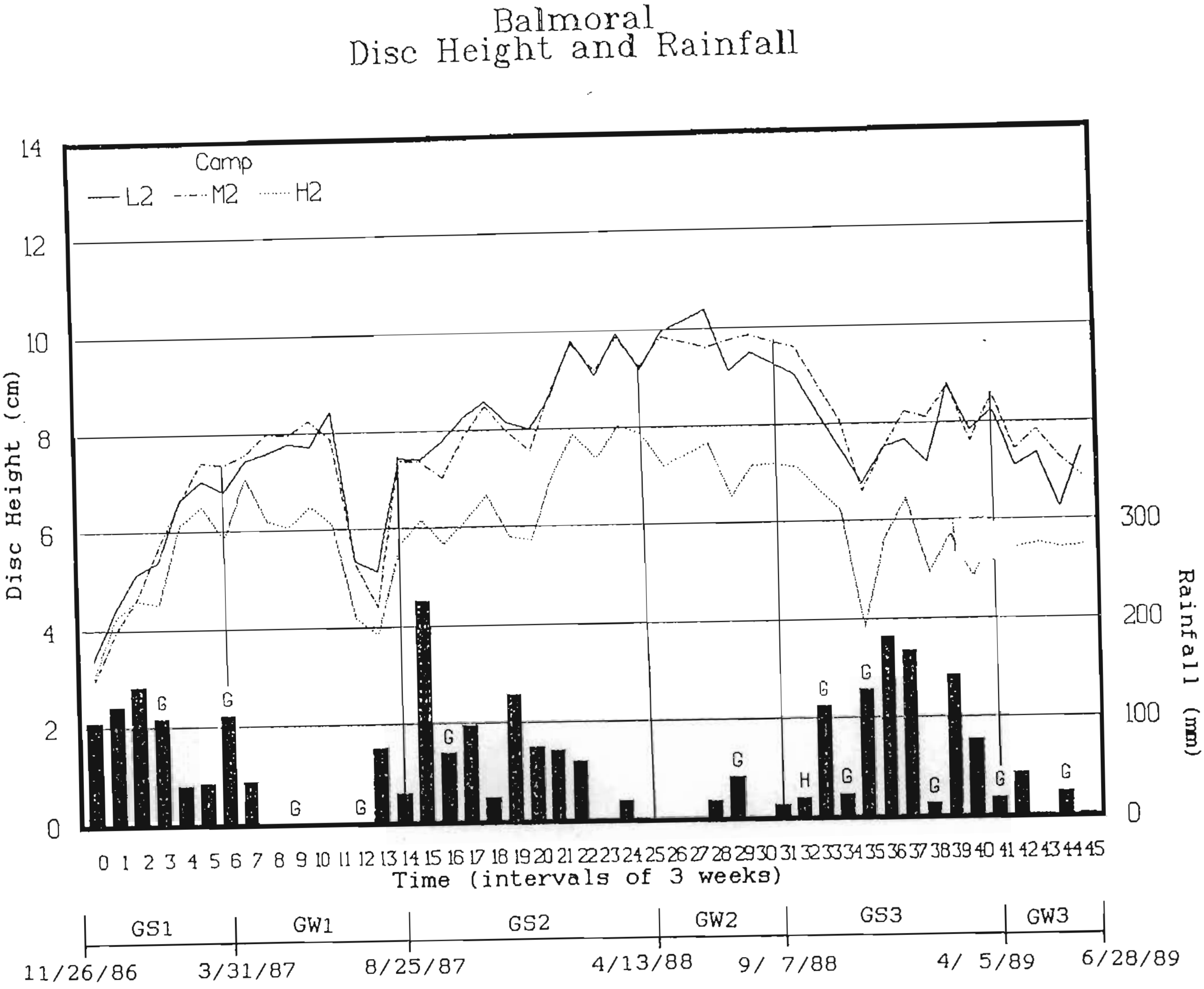


Fig. 12.3b. Disc height (cm) at each measuring period for each camp of group 2 at Site 6. Also indicated is the rainfall (mm) that occurred during each period and the periods during which each camp in the group was grazed (G = whole group; where the whole group was not grazed the camps from the respective treatments are indicated). The vertical lines show the grass summers (GS) and grass winters (GW) (which are labelled below the X-axis). (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

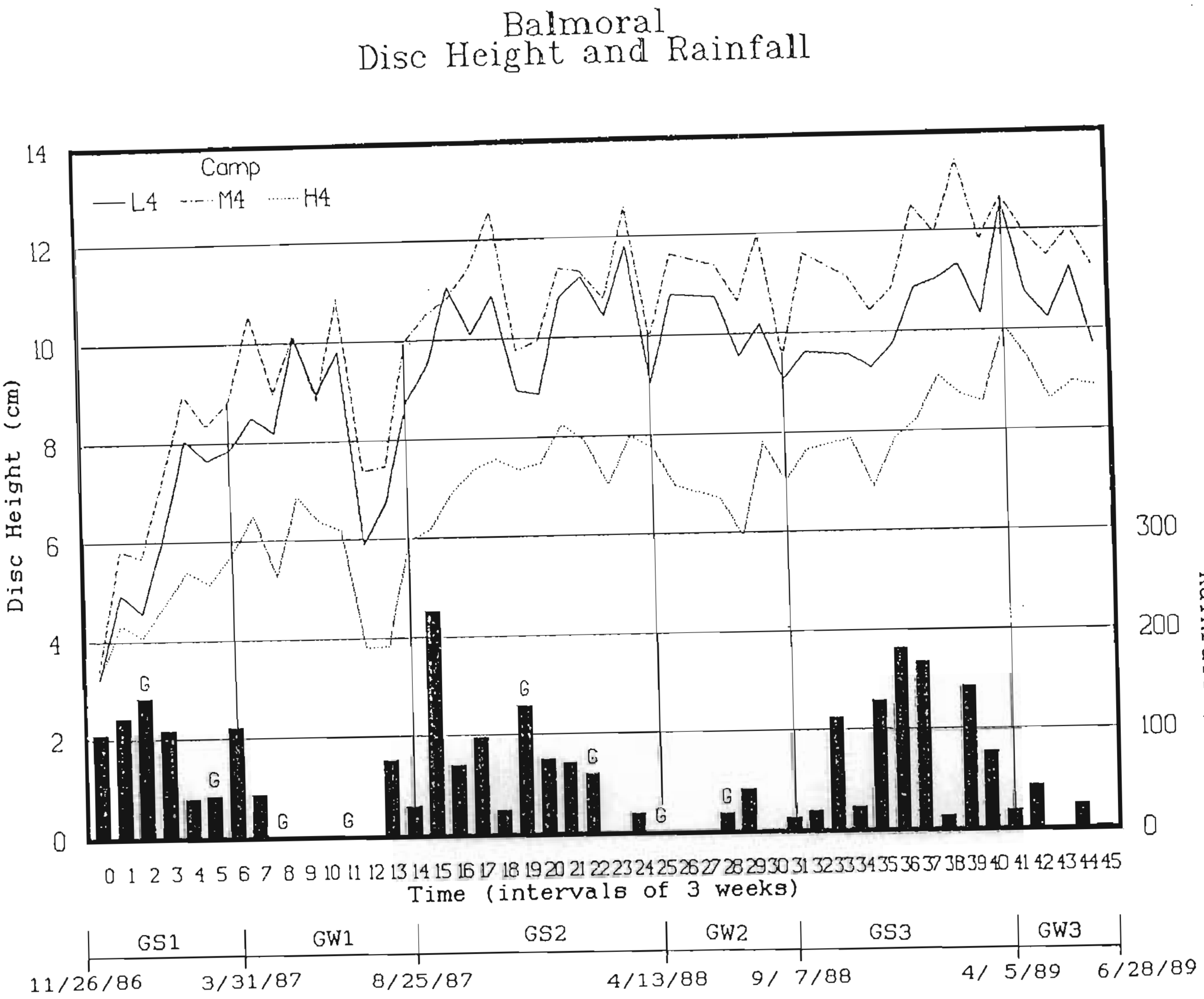


Fig. 12.3c. Disc height (cm) at each measuring period for each camp of group 4 at Site 6. Also indicated is the rainfall (mm) that occurred during each period and the periods during which each camp in the group was grazed (G). The vertical lines show the grass summers (GS) and grass winters (GW) (which are labelled below the X-axis). (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

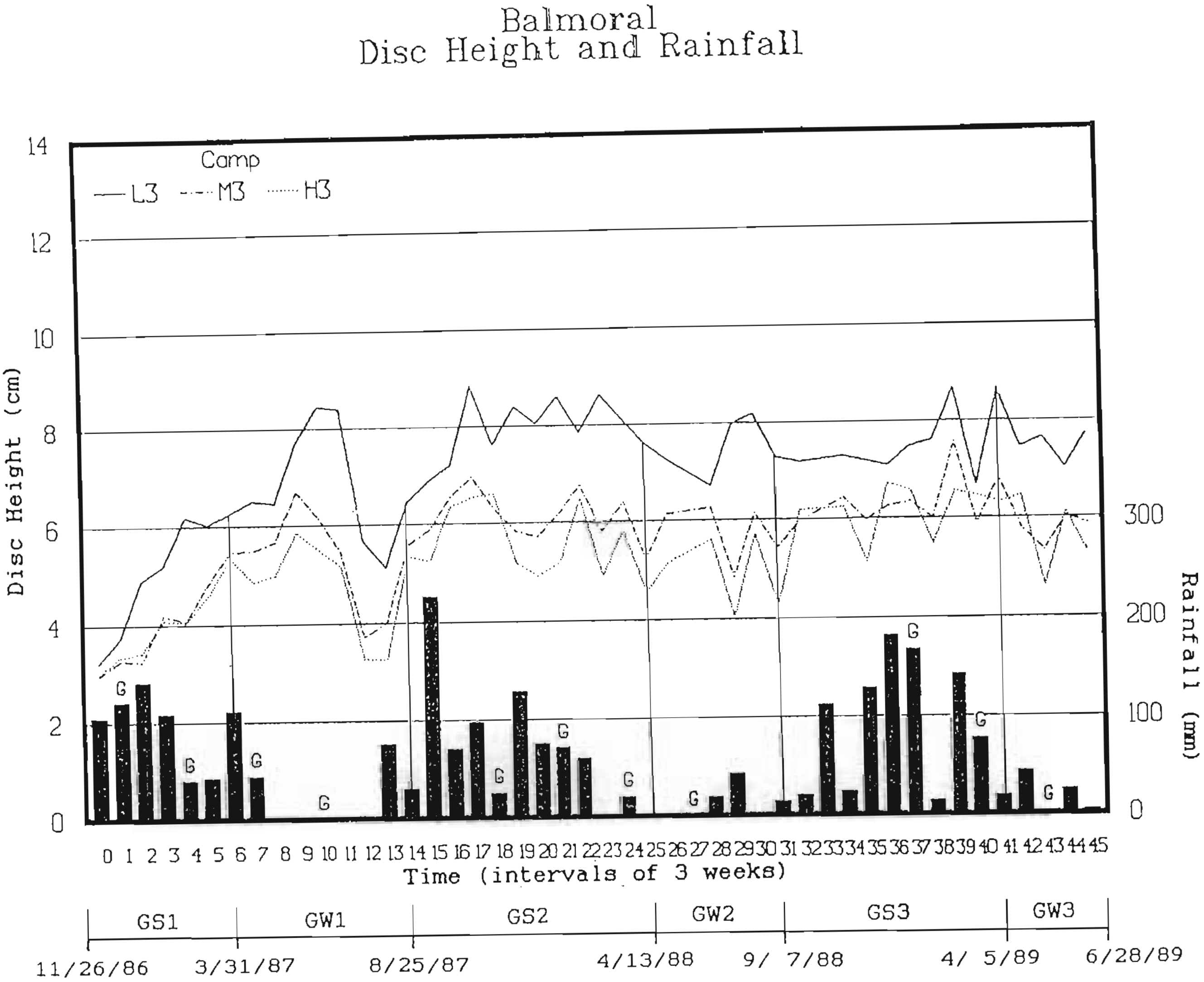
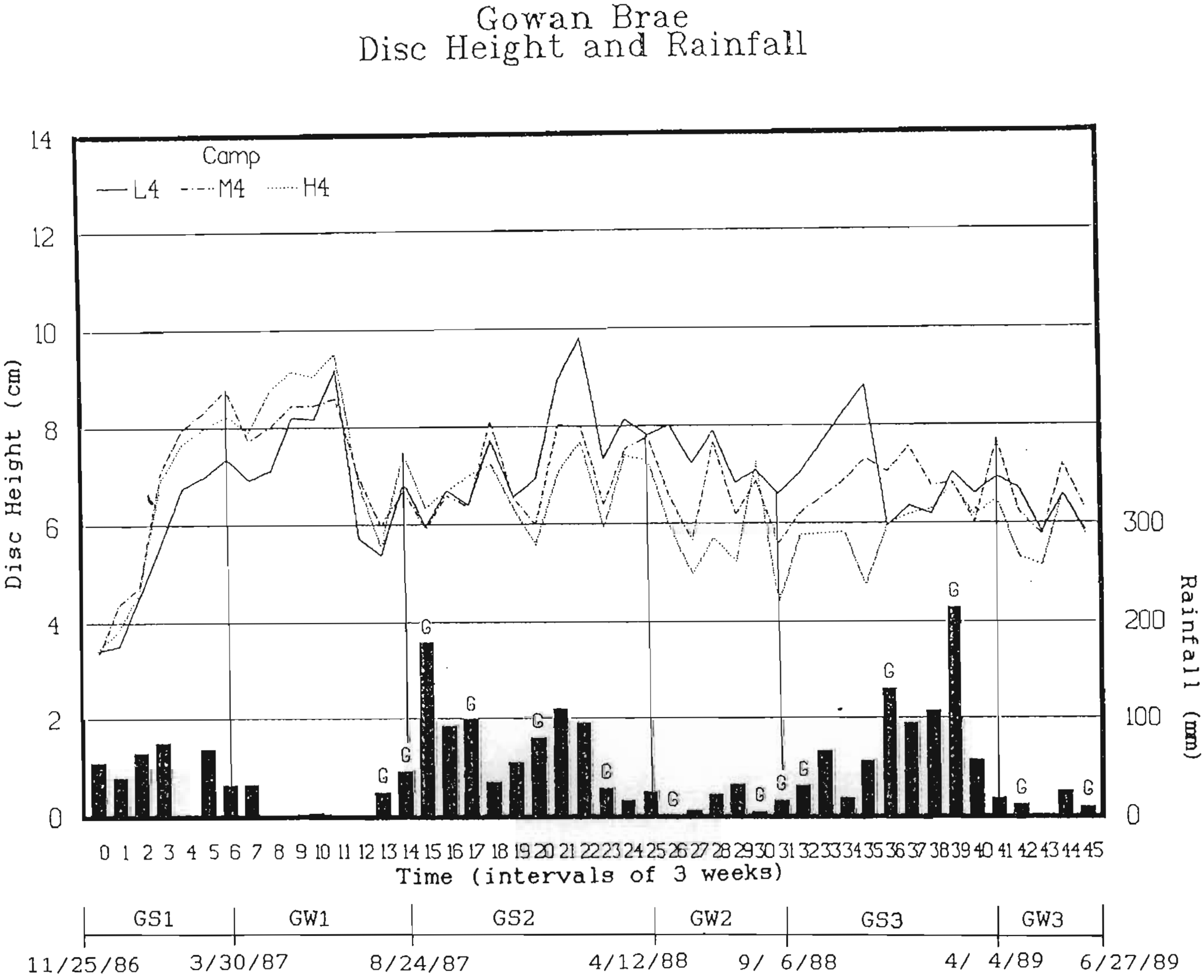


Fig. 12.3d. Disc height (cm) at each measuring period for each camp of group 3 at Site 6. Also indicated is the rainfall (mm) that occurred during each period and the periods during which each camp in the group was grazed (G). The vertical lines show the grass summers (GS) and grass winters (GW) (which are labelled below the X-axis). (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)



Gowan Brae
Disc Height and Rainfall

Fig. 12.4a. Disc height (cm) at each measuring period for each camp of group 4 at Site 7. Also indicated is the rainfall (mm) that occurred during each period and the periods during which each camp in the group was grazed (G). The vertical lines show the grass summers (GS) and grass winters (GW) (which are labelled below the X-axis). (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

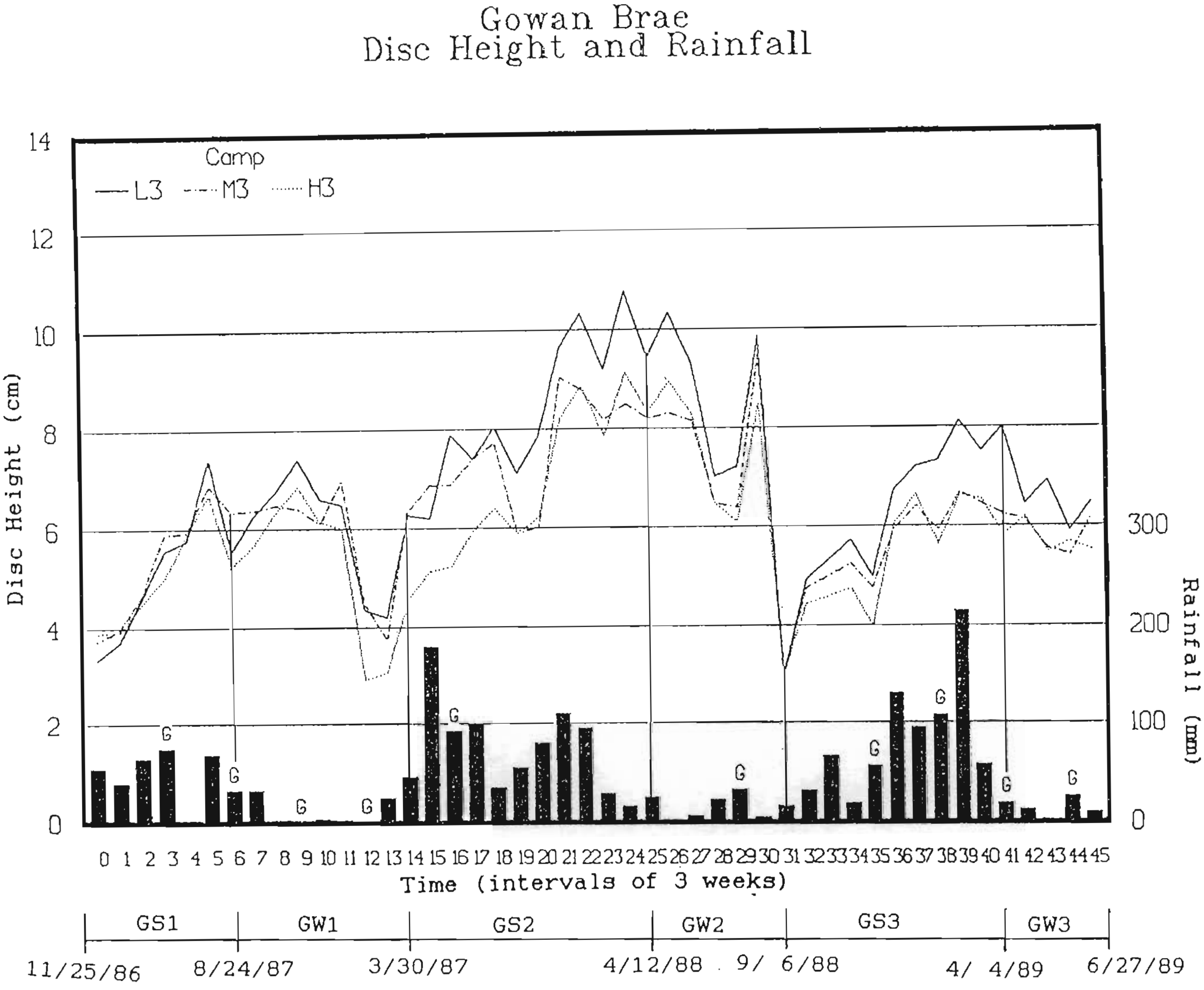


Fig. 12.4b. <u>Disc height (cm)</u> at each measuring period for each camp of <u>group 3 at Site 7</u>. Also indicated is the rainfall (mm) that occurred during each period and the periods during which each camp in the group was grazed (G). The vertical lines show the grass summers (GS) and grass winters (GW) (which are labelled below the X-axis). (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

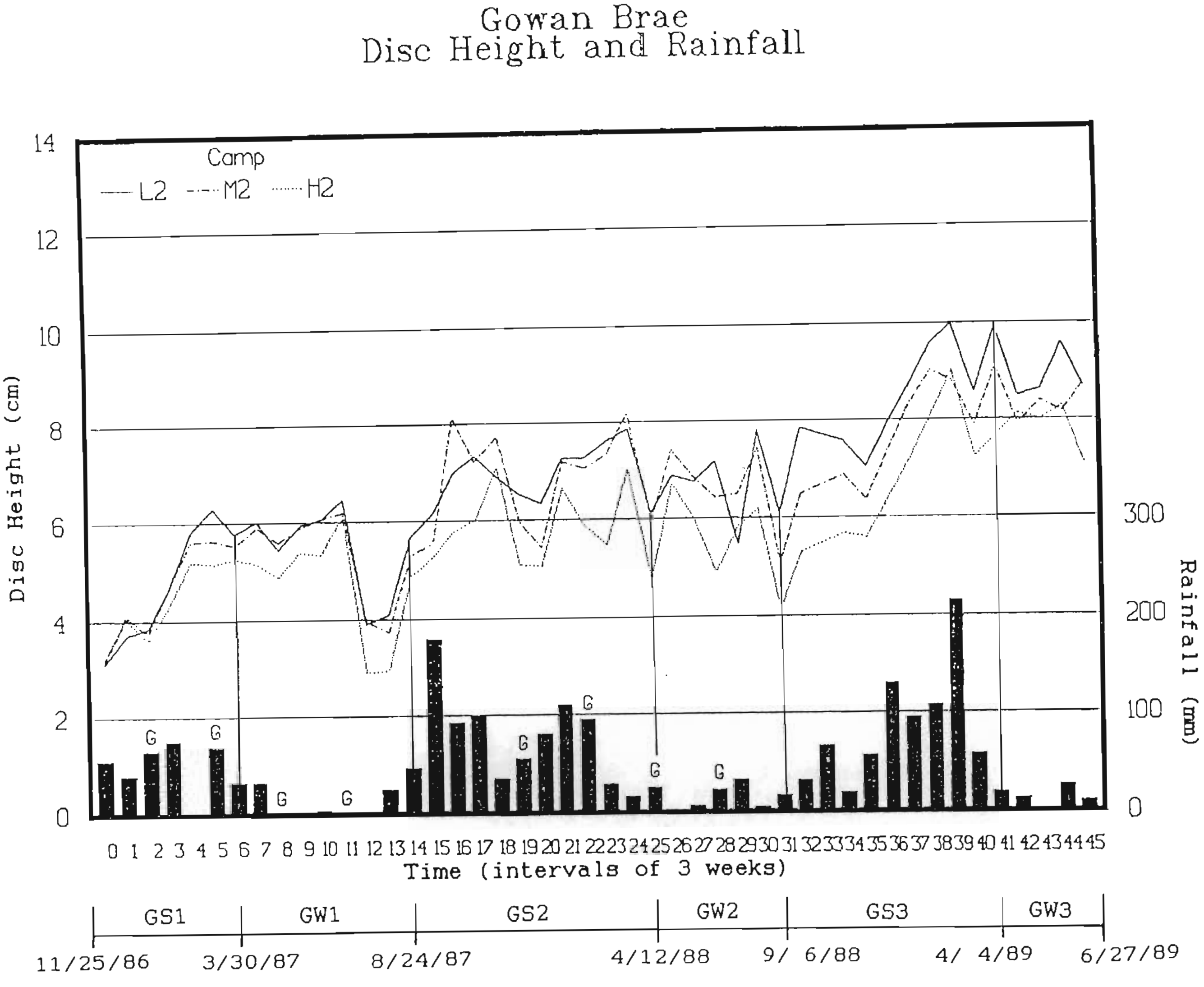


Fig. 12.4c. Disc height (cm) at each measuring period for each camp of group 2 at Site 7. Also indicated is the rainfall (mm) that occurred during each period and the periods during which each camp in the group was grazed (G). The vertical lines show the grass summers (GS) and grass winters (GW) (which are labelled below the X-axis). (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

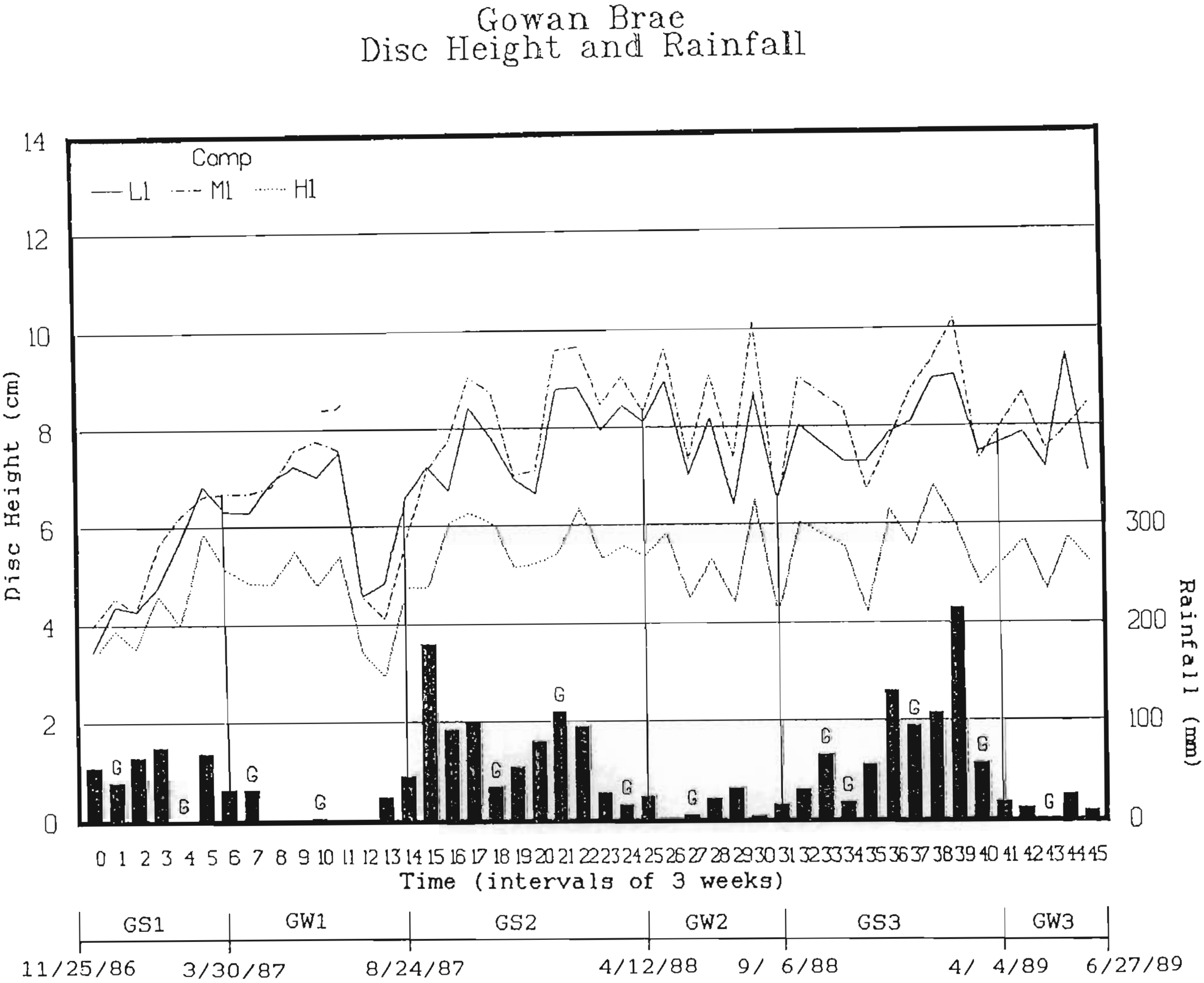


Fig. 12.4d. Disc height (cm) at each measuring period for each camp of group 1 at Site 7. Also indicated is the rainfall (mm) that occurred during each period and the periods during which each camp in the group was grazed (G). The vertical lines show the grass summers (GS) and grass winters (GW) (which are labelled below the X-axis). (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

burnt at the start of the trials, and for the same reasons as for the Tall Grassveld (Section 8.3), it was decided not to burn the camps that had been rested during the first summer at the end of the following winter. Burning in subsequent seasons was based on the same criteria as for the Tall Grassveld (Section 8.3).

For the same reasons given for the Lowveld (Section 4.3), the paired data for calibrating the disc meter were combined and a general calibration curve was developed for the Sour Sandveld which is as follows:

$$H = 385 + 320{,}5D \qquad r^2 = 0{,}65 \quad **$$

where
H = Herbage mass (kg/ha)
D = Disc height (cm)

Once again, it should be noted that by using a single general calibration curve for herbage mass on disc height, the changes in HM will follow an identical pattern to the changes in DH.

The grass summers and winters which were identified for the three seasons are shown in Figs 12.3 and 12.4. From these figures some general observations may be made.

a. Although DH followed the seasonal pattern in rainfall, it was not as clear as in the other two veld types.

b. The influence of rainfall was modified by the effects of grazing.

c. The lengths of the grass summers and grass winters varied between seasons.

d. The effect that stocking rate had on HM is particularly noticeable for the heavy stocking rate treatments.

e. Mean DH seldom dropped below 4 cm (or a HM of 1667 kg/ha). This is lower than the 2000 kg/ha grazing cut-off suggested by Turner (1988). When camps were grazed to a DH of < 4 cm or a HM of about 1700 kg/ha, they were grazed down to a height consistent with the concept of a grazing cut-off suggested by Turner *1988). The discrepancy between this value and the 2000 kg/ha suggested earlier by Turner (1988) may lie in the use of the general calibration equation in these analyses and not the specific calibration curve for that time used by Turner (1988).

12.4 CHANGES IN ANIMAL PERFORMANCE

The mean animal cumulative mass gains (CMG) for Sites 6 and 7 are presented in Figs 12.5 and 12.6 respectively. From these data changes in mean IAP with time over 45 time periods

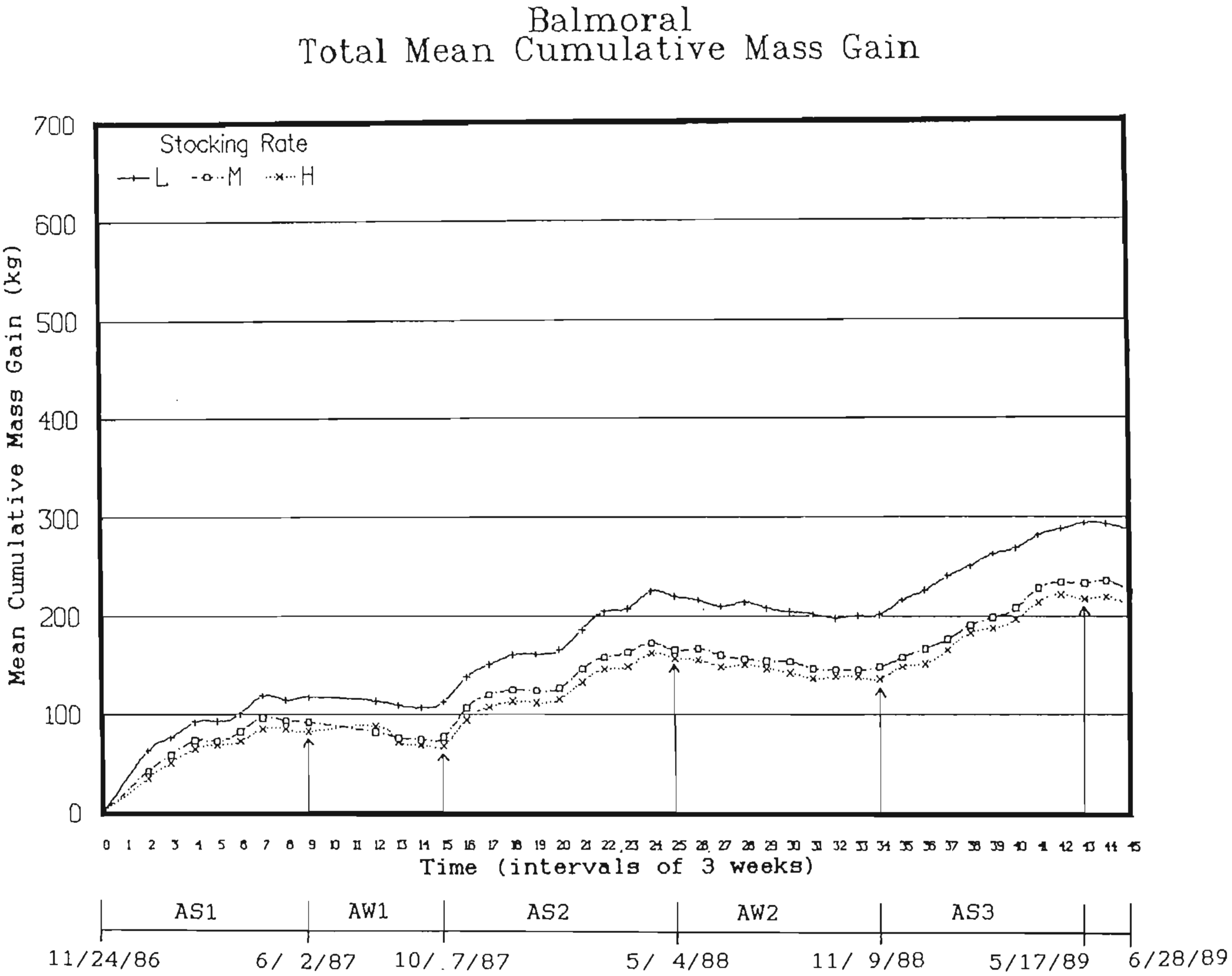


Fig. 12.5. The mean cumulative mass gain (kg) over the three year experimental period at Site 6 for each stocking rate treatment. The vertical arrows show the animal summers (AS) and animal winters (AW) (which are labelled below the X-axis). (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

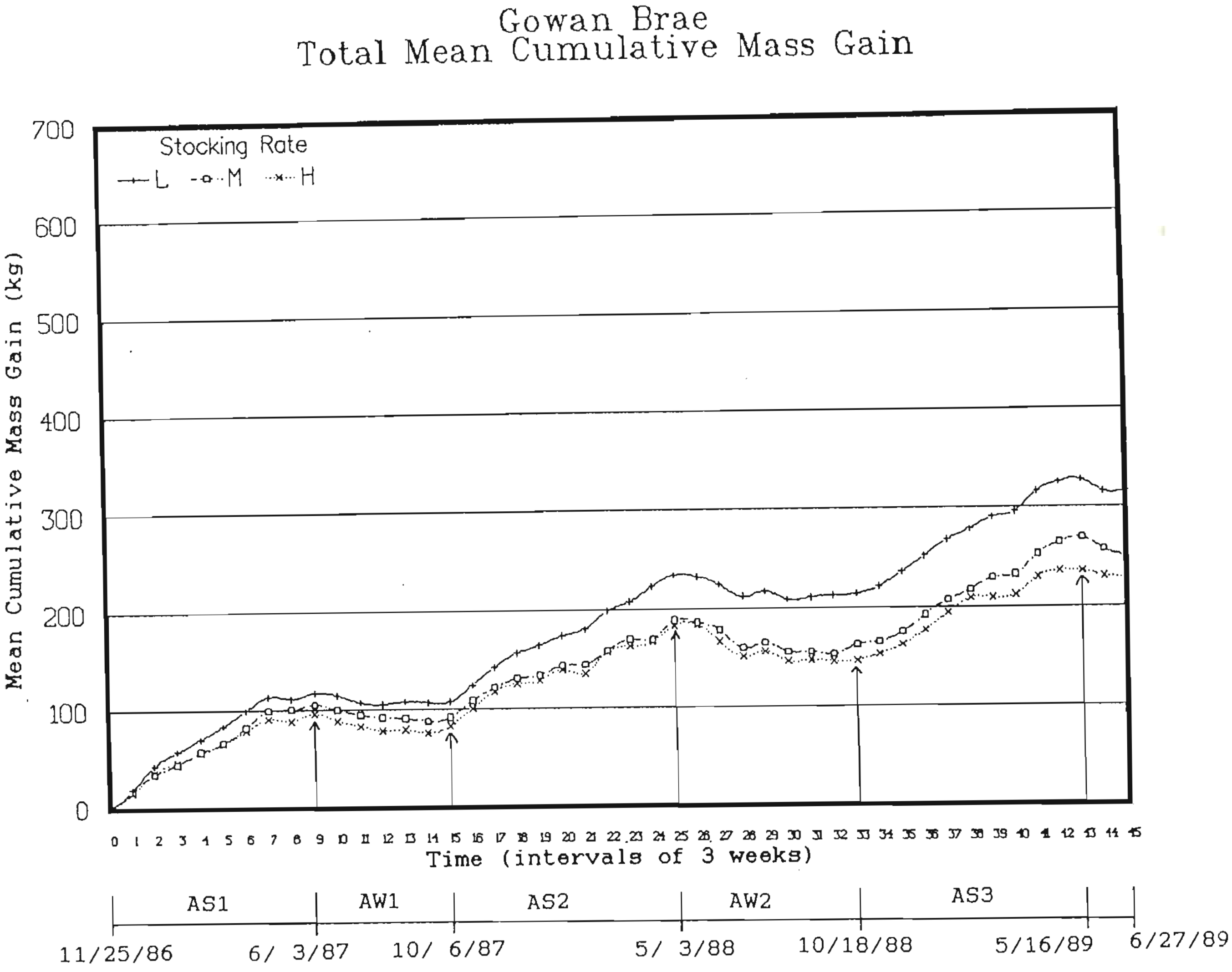


Fig. 12.6. The <u>mean cumulative mass gain (kg)</u> over the three year experimental period at <u>Site 7</u> for each stocking rate treatment. The vertical arrows show the animal summers (AS) and animal winters (AW) (which are labelled below the X-axis). (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

(these periods coincide with those for the disc meter data) are clearly seen. The animal summers and winters which were identified are shown in these figures.

Polynomials were fitted to the cumulative mass gain data for each stocking rate at each site (Figs 12.7 and 12.8 for Sites 6 and 7 respectively). Stocking rates (LSU/ha) were calculated from the fitted data using the procedure described by Turner (1988). The IAP and stocking rate data are summarised in Table 12.3.

The following should be noted with respect to animal performance in the Sour Sandveld.

a. A strong consistent effect of stocking rate on IAP which had been anticipated did materialise for all seasons (Table 12.3).

b. The length of time over which animals gained mass varied between seasons. It remained consistent between stocking rate treatments within seasons at each site but some variation occurred between sites (Figs 12.7 and 12.8 and Table 12.3). (The second animal winter was 3 weeks shorter at Site 7 than at Site 6 and therefore the third animal summer was 3 weeks longer at Site 7 than at Site 6.)

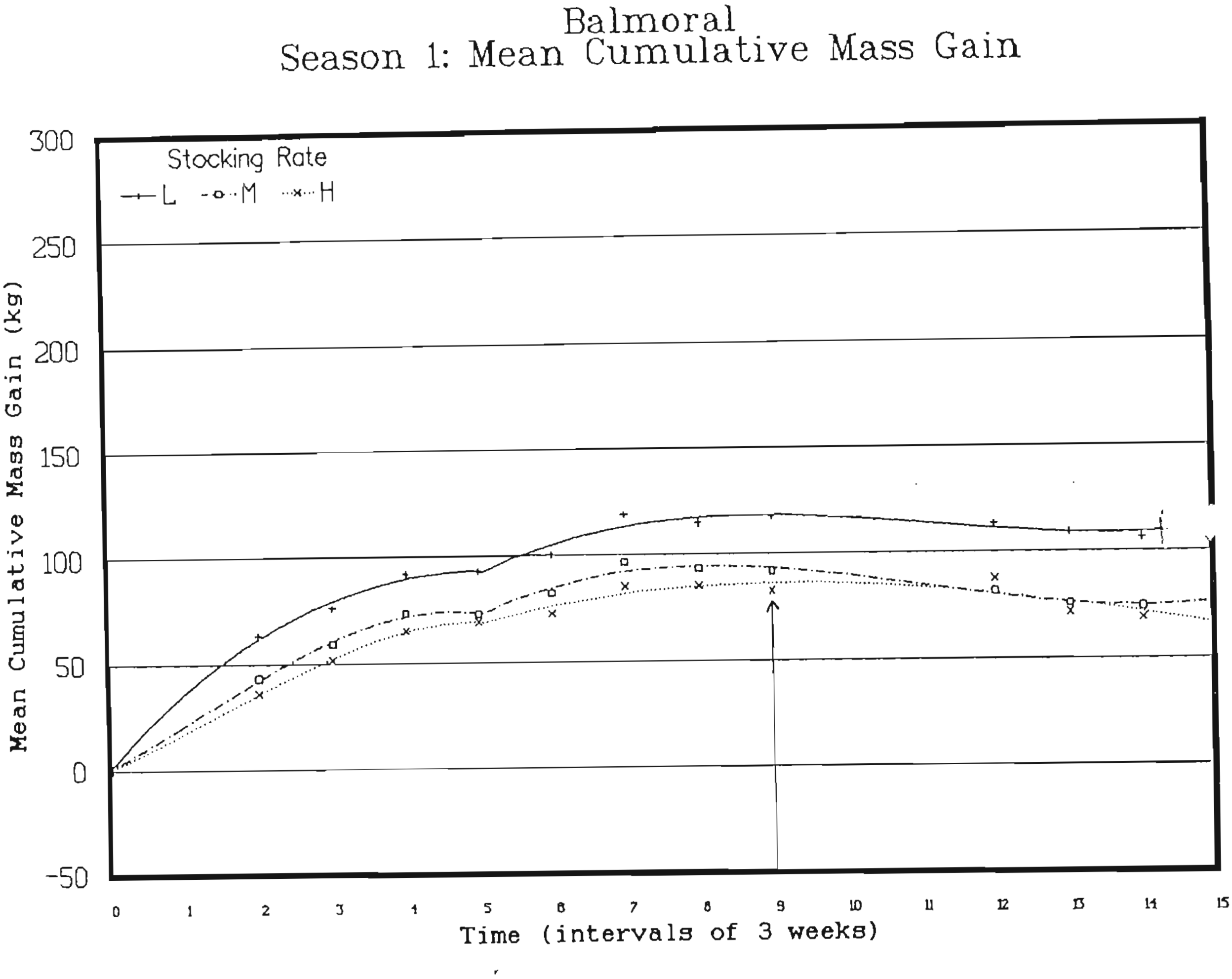


Fig. 12.7a. The fitted mean cumulative mass gain (kg) over the first summer and winter at Site 6 for each stocking rate treatment. The vertical arrow indicates the division between the animal summer and winter. The periods are equivalent to the corresponding periods in Fig. 12.5. (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

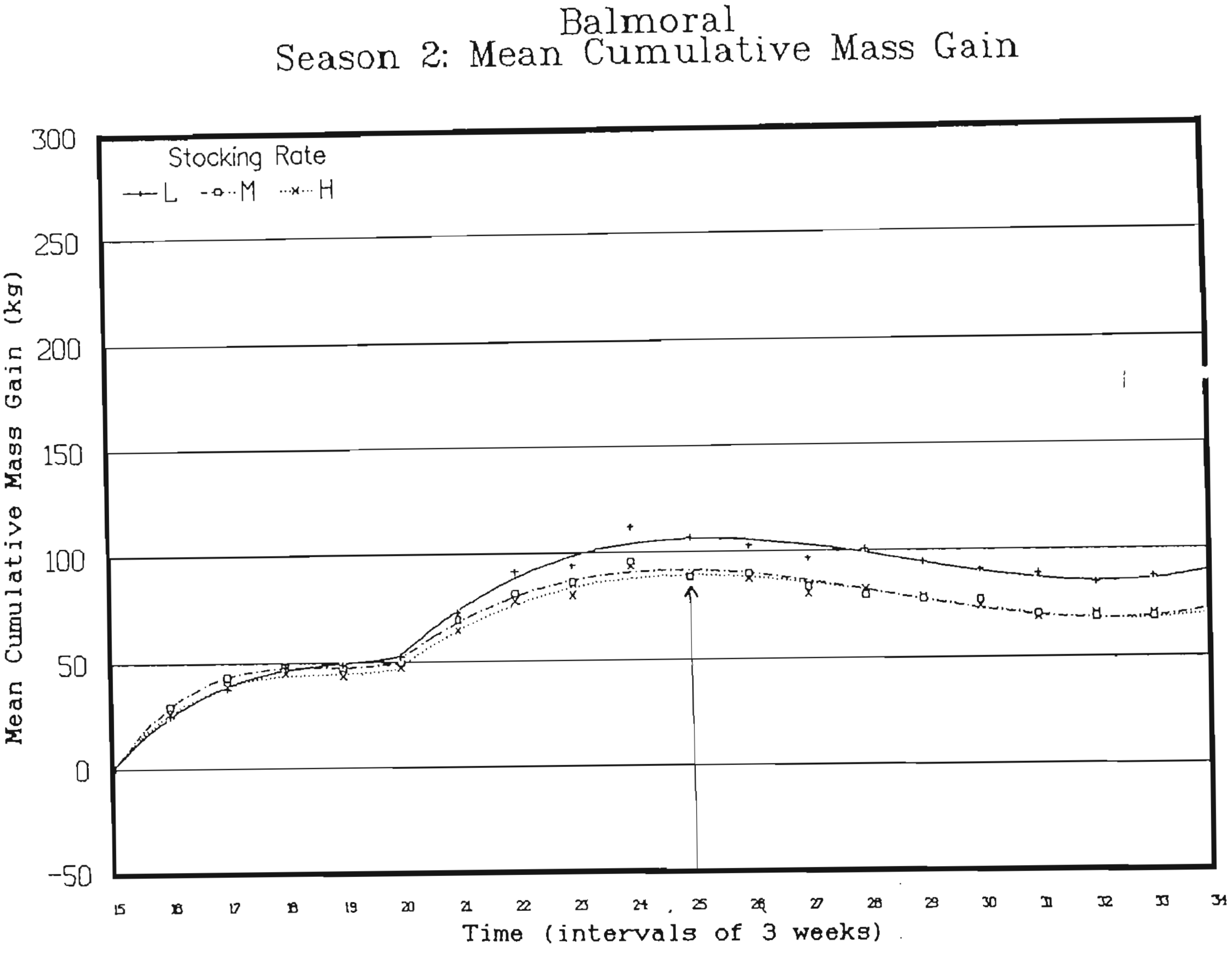


Fig. 12.7b. The fitted mean cumulative mass gain (kg) over the second summer and winter at Site 6 for each stocking rate treatment. The periods are equivalent to the corresponding periods in Fig. 12.5. The vertical arrow indicates the division between the animal summer and winter. (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

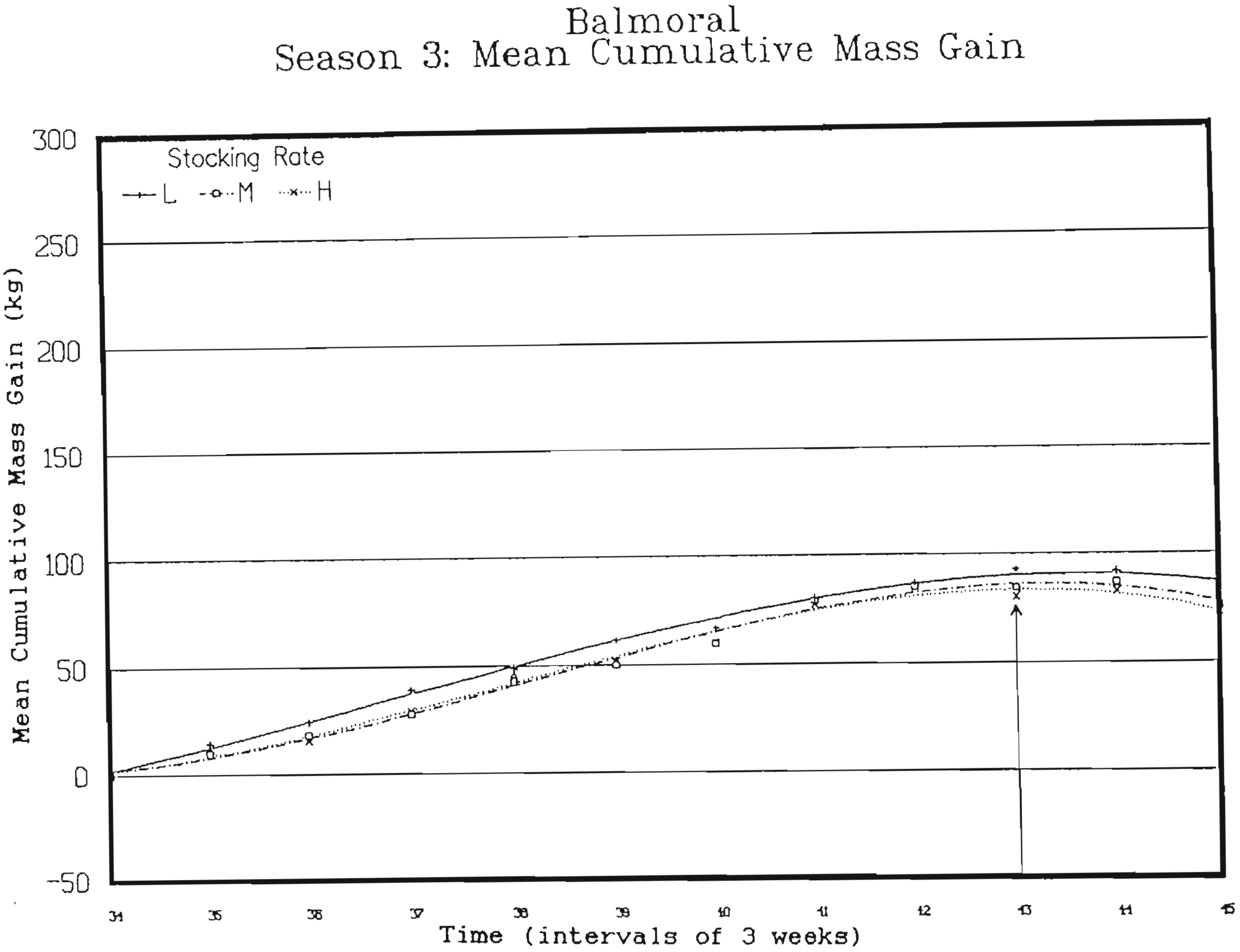


Fig. 12.7c. The fitted mean cumulative mass gain (kg) over the third summer and the start of the third winter at Site 6 for each stocking rate treatment. The periods are equivalent to the corresponding periods in Fig. 12.5. The vertical arrow indicates the division between the animal summer and winter. (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

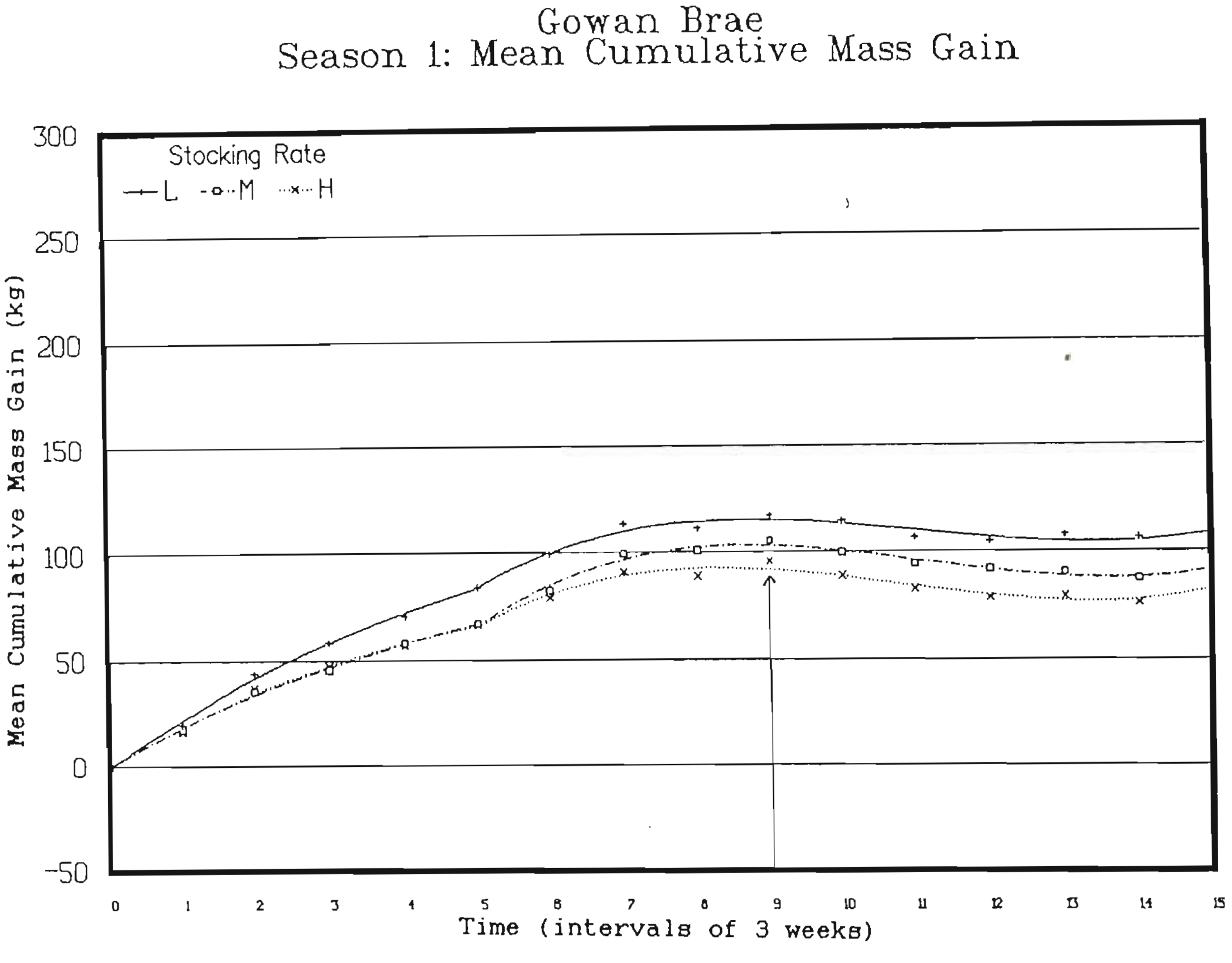


Fig. 12.8a. The <u>fitted mean cumulative mass gain (kg)</u> over the <u>first summer and winter at Site 7</u> for each stocking rate treatment. The periods are equivalent to the corresponding periods in Fig. 12.6. The vertical arrow indicates the division between the animal summer and winter. (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

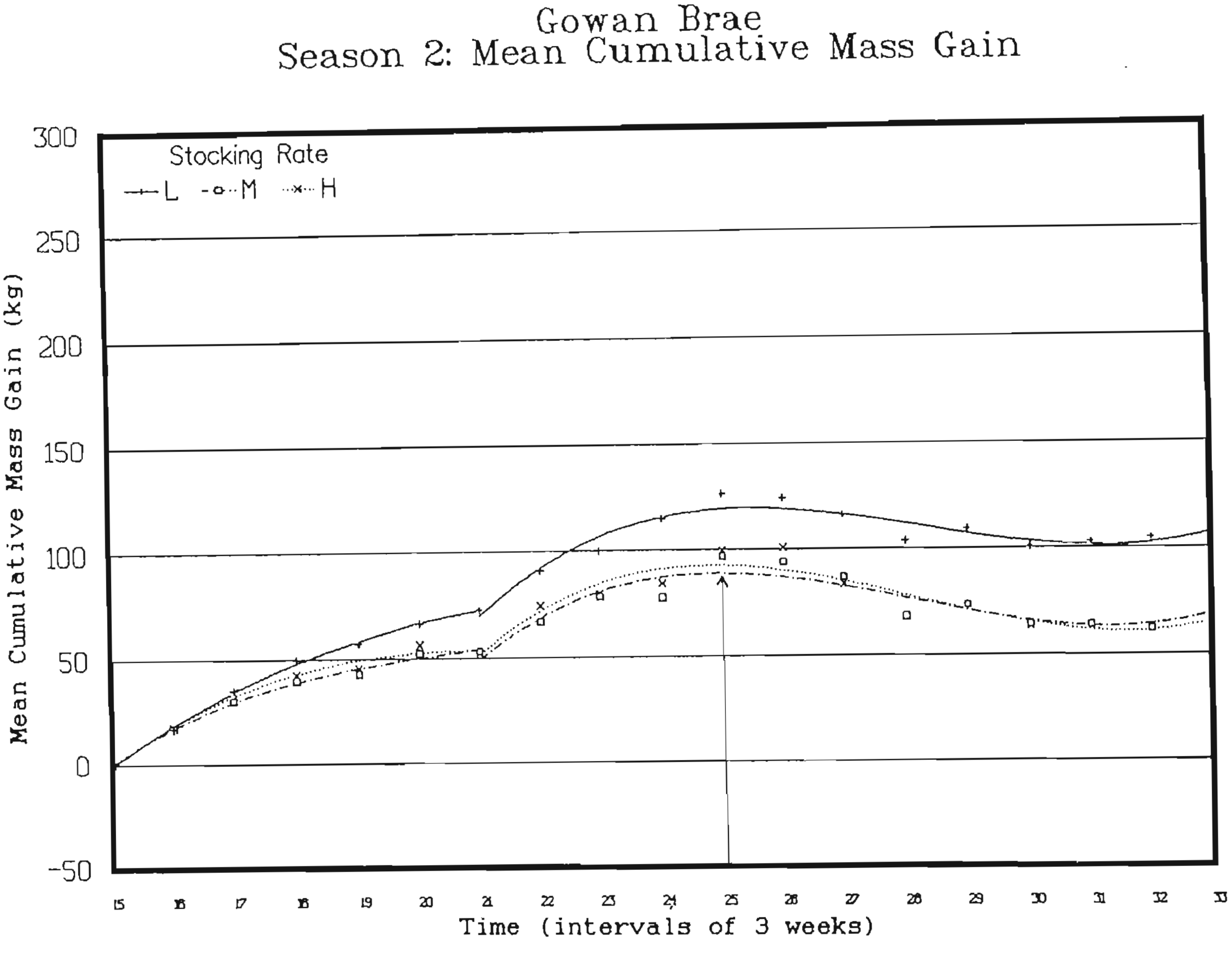


Fig. 12.8b. The fitted mean cumulative mass gain (kg) over the second summer and winter at Site 7 for each stocking rate treatment. The periods are equivalent to the corresponding periods in Fig. 12.6. The vertical arrow indicates the division between the animal summer and winter. (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

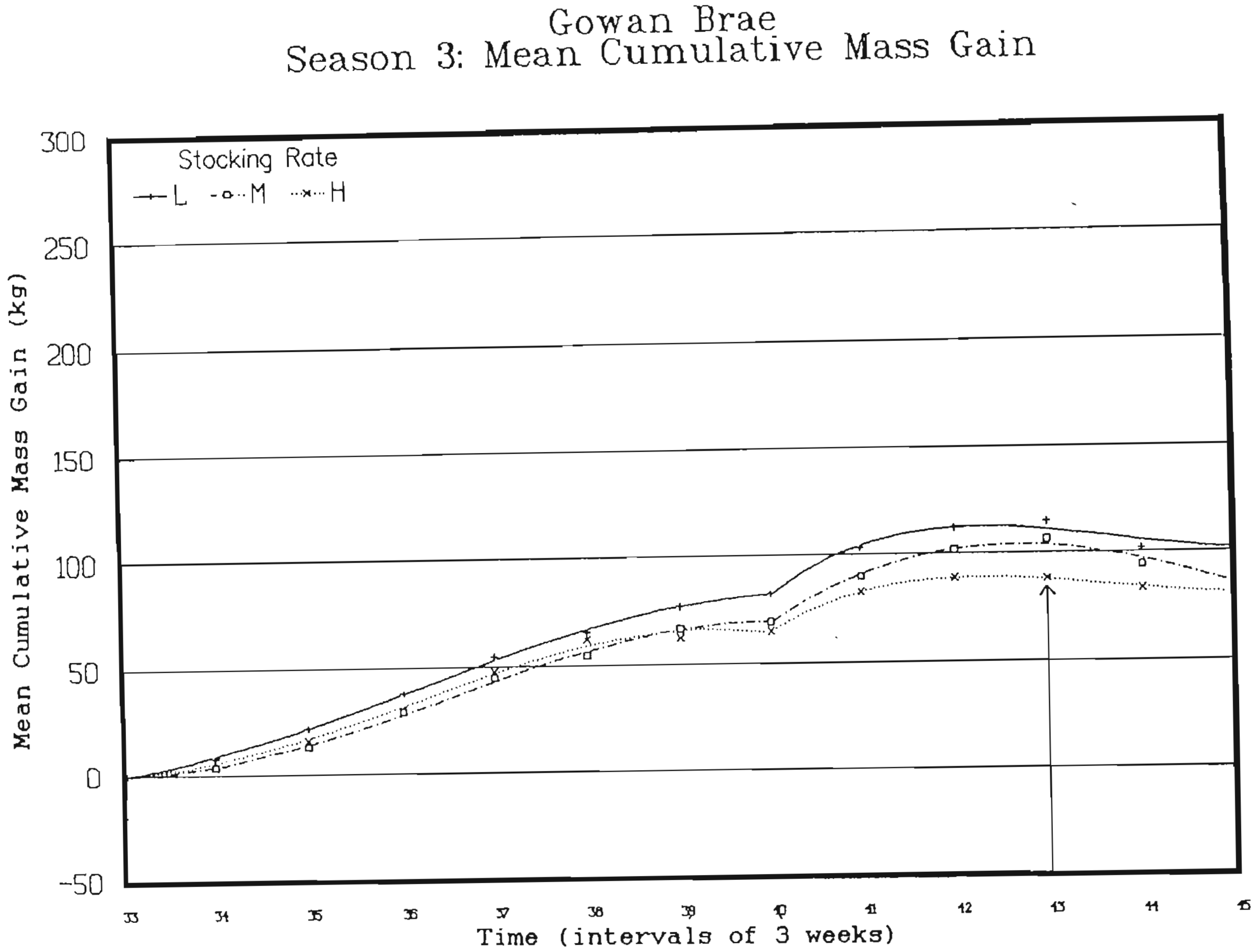


Fig. 12.8c. The fitted mean cumulative mass gain (kg) over the third summer and the start of the third winter at Site 7 for each stocking rate treatment. The periods are equivalent to the corresponding periods in Fig. 12.6. The vertical arrow indicates the division between the animal summer and winter. (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

Table 12.3 A summary of individual animal performance and stocking rate for Sites 6 and 7 derived from the fitted data. (The periods coincide with those in Figures 12.7 and 12.8 for the respective sites.) (L, M and H are the light, moderate and heavy stocking rate treatments respectively.)

Site, & Periods	Length of period of gains/ losses (weeks)	Gains/losses (kg)			Actual Stocking Rate (LSU/ha)		
		L	M	H	L	M	H
Site 6							
0 – 9	27	118	94	87	0,20	0,29	0,35
9 – 15	18	– 6	–17	–20	0,12	0,16	0,21
0 – 15	45	112	77	67	0,17	0,24	0,30
15 – 25	30	107	92	90	0,20	0,25	0,32
25 – 34	27	–16	–19	–20	0,13	0,17	0,22
15 – 34	57	91	73	70	0,17	0,21	0,27
34 – 43	27	91	87	84	0,18	0,25	0,31
0 – 43	129	294	237	221	0,17	0,23	0,29
Site 7							
0 – 9	27	116	103	92	0,24	0,31	0,38
9 – 15	18	– 6	–11	–10	0,13	0,18	0,23
0 – 15	45	110	92	82	0,20	0,26	0,32
15 – 25	30	120	90	93	0,22	0,27	0,35
25 – 33	24	–13	–21	–28	0,14	0,18	0,22
15 – 33	54	107	69	65	0,18	0,23	0,30
33 – 43	30	111	104	90	0,20	0,27	0,32
0 – 43	129	328	265	237	0,19	0,25	0,31

c. A mid-season decline in IAP occurred in the first two seasons at Site 6 and in all three seasons at Site 7.

The same reasons for the occurrence of mid-season declines in IAP may be offered here as was offered for the Tall Grassveld. But why the difference between the two sites in the third season? The winter lick was made available to the cattle at Site 6 from the beginning of period 38 and at Site 7 from the beginning of period 39 in the third season. But the mid-season decline in IAP appeared to start at period 38 at Site 7 (Fig. 12.8c). It could be speculated, therefore, that had a rumen stimulating lick been made available at period 38 at Site 7 as well, this mid-season decline may have been prevented. (A twist perhaps, but it was the inconvenience factor (discussed in Section 9.3) of rain that caused the delay in the feeding of winter lick at Site 7!)

CHAPTER 13

HERBAGE MASS COMPONENT MODELS FOR THE SOUR SANDVELD

CHAPTER 13

HERBAGE MASS COMPONENT MODELS FOR THE SOUR SANDVELD

13.1 A MODEL FOR PREDICTING HERBAGE MASS AT THE END OF THE GRASS SUMMER FOR THE SOUR SANDVELD

Data from both sites were used to develop the model. The total data set therefore included data from 12 camps at each of 2 sites and for each of 3 seasons (or 72 sets of data). The parameters of the model are as follows.

a. Residual HM (kg/ha) at the end of the grass summers (Section 12.3). This was calculated from DH recorded at that time using the general calibration curve for the DM for the Sour Sandveld.

b. Stocking rate (LSU GDs/ha) for the grass summers (the calculation of which is explained in Section 5.1).

c. Veld condition which was indexed simply by the sum of the proportions of Themeda triandra and Tristachya leucothrix (Turner, 1988).

d. Residual HM (kg/ha) at the end of the preceding grass winter. This was calculated from the DH recorded at that time using the general calibration curve for the DM for the Sour Sandveld. This was included because it was once again felt that it would be reasonable to assume that some of this residual herbage would contribute to the HM at the end of the summer or at least that it may have been grazed so that more of the newly grown material would have survived grazing. It is important to note that the residual value included for burnt veld was 0 kg/ha despite the mean DM readings of about 3 cm that were obtained for recently burnt veld.

e. The proportion species composition of Eragrostis plana. (The reason for including this factor was the high mean DHs that were recorded in camps L4 and M4 at Site 6 (Fig. 12.3c). It was obvious that it was the E. plana in these camps that gave rise to the very high DHs).

The model that was developed is as follows:

$$H_S = 2240 - 8{,}56G_S + 10V + 0{,}405H_W + 33{,}38Ep$$

$$r^2 = 0{,}79 \quad **$$

where

H_S = Residual herbage mass (kg/ha) at the end of the grass summer

G_S = Grazing days (LSU GDs/ha) for the grass summer

V = Veld condition index (the sum of the proportions of Themeda triandra and Tristachya leucothrix)

H_W = Residual herbage mass (kg/ha) at the end of the preceding grass winter

Ep = The proportion of Eragrostis plana

No real advantage was gained from the development of separate models for grazed and rested veld (r^2 = 0,70 and 0,96 respectively) relative to the model for the combined data (r^2 = 0,79) despite the high r^2 for the rested veld. The high r^2 value for the rested veld can be attributed to the low degrees of freedom (17) compared with the number for the grazed veld (53) and the combined data (71). There were insufficient burnt camps in the second and third seasons to warrant the development of separate models for burnt and unburnt veld.

What is surprising is that rainfall was not significant (and had a coefficient of only 0,015 i.e. every additional 100 mm would have made a difference of only 1,5 kg/ha). This is not easily explained. There are two factors which may have contributed to this circumstance.

a. Effective rainfall rather than absolute rainfall may have been a very important contributing factor in the Sour Sandveld. Site 6 is situated on clay soils. Therefore runoff would be expected to be high because of the low infiltrations rates that occur in clay soils. Even though the seasons rainfall were all well above average, the effective rainfall may nonetheless have been low. Conversely, Site 7, which experienced a very dry season in the first summer, is situated on sandy soils. Infiltration rates would be expected to be high. In a dry year effective rainfall may therefore be expected to be high.

b. The effects of the stocking rates that were applied were greater than had been expected. Therefore, if camps were relatively heavily grazed, the expected differences in HM due to differences in rainfall would not have materialised because, under these conditions, most of the palatable grass would be expected to have been grazed. Heavy grazing would therefore have dampened the expected differences due to rainfall.

13.2 A MODEL FOR PREDICTING HERBAGE MASS AT THE END OF THE GRASS WINTER FOR THE SOUR SANDVELD

Data from both sites were used to develop the model. The total data set therefore included data from 12 camps at each of 2 sites and for each of 2 seasons (or 48 sets of data). The parameters of the model are as follows.

a. Residual HM (kg/ha) at the end of the grass winter (identified in Section 12.3). This was calculated from DH recorded at that time using the general calibration curve for the DM for the Sour Sandveld.

b. The effect of grazing (LSU GDs/ha) during the grass winter (the calculation of which is explained in Section 5.1).

c. Residual HM (kg/ha) at the end of the preceding grass summer (see Section 12.3) which was calculated from DH recorded at that time using the general calibration curve for the DM meter for the Tall Grassveld.

The model that was developed is as follows:

$$H_W = -157 - 8{,}7G_W + 0{,}9606H_S$$

$$r^2 = 0{,}84 \quad **$$

where

H_W = Residual herbage mass (kg/ha) at the end of the grass winter

G_W = Grazing days (LSU GDs/ha) for the grass winter

H_S = Residual herbage mass (kg/ha) at the end of the preceding grass summer

13.3 DISCUSSION

Once again, two coefficients are of interest in both these models.

a. Coefficients for the effect of stocking rate. In this case the effects of stocking rate are shown to be similar for the summer and winter season. A possible reason for the difference between this veld and the Tall Grassveld in this respect (see Section 9.3) is not clear. However, it should also be noted that both these coefficient reflect closely the commonly used value of 10 kg dry matter intake per animal unit per day.

b. Coefficients for the contribution of HM carried over from the previous season to the HM at the end of the current seasons. From the coefficients, it is implicit that 40% of the residual HM from the grass winter will contribute to the HM at the end of the following grass summer and that about 96% of the HM at the end of the grass summer will contribute to the HM at the end of the following grass winter. These coefficients are much greater than for the Tall Grassveld. Nonetheless, they are intuitively very satisfactory, since one would, as in the Tall Grassveld, anticipate a far higher rate of decay during a wet period than during a dry period. In addition, however, the grasses of the Sour Sandveld (e.g. Elionurus muticus, Eragrostis plana and E. curvula) have a far greater leaf tensile strength than those of the Tall Grassveld and it is therefore likely that there would be less leaf drop from the grasses of the Sour Sandveld than from the Tall Grassveld.

CHAPTER 14

AN ANIMAL PERFORMANCE COMPONENT MODEL FOR THE SOUR SANDVELD

CHAPTER 14

AN ANIMAL PERFORMANCE COMPONENT MODEL FOR THE SOUR SANDVELD

For the same reasons as outlined for the Tall Grassveld, there is really only a need for a model to predict animal gains during the summer. Winter animal performance data will have very little practical meaning.

The effect of stocking rate on IAP was marked within any season. However, seasonal differences obviously also affected IAP between seasons. It was anticipated that other factors such as, for example, the length of the (summer) rainfall period, veld condition (both the proportion of palatable and some of the unpalatable species), rainfall and available herbage (as reflected in HM) could have had an important influenced on IAP.

Data from both sites were used to develop the model. The total data set therefore included data from 3 stocking rate treatments at each of 2 sites and for each of 3 seasons (or 27 sets of data). The parameters of the model are as follows.

a. Animal mass gains (kg/animal) over the animal summer (Table 12.3).

b. Stocking rate (LSU/ha) for the animal summer.

c. Veld condition which was indexed simply by the sum of the proportions of Themeda triandra and Tristachya leucothrix (Turner, 1988).

d. Residual HM (kg/ha) at the end of the current grass summer. This was calculated from DH recorded at that time using the general calibration curve for the DM for the Sour Sandveld.

e. The sum of the proportions of Elionurus muticus and Eragrostis plana in the sward.

The model which was developed is as follows:

$$G = 197{,}8 - 185S_5 - 1{,}18V - 0{,}008H_5 - 0{,}4U$$

$r^2 = 0{,}78$ **

where

G = Individual animal mass gain (kg/animal/season) for the animal summer

S_5 = Stocking rate (LSU/ha) for the animal summer

V = Veld condition index (the sum of the proportions of Themeda triandra and Tristachya leucothrix)

H_5 = Residual herbage mass (kg/ha) at the end of the grass summer

U = The sum of the proportions of Elionurus muticus and Eragrostis plana in the sward

It is surprising that grass summer rainfall was rejected for this model. In view of the heavy grazing that occurred, and the non significant effect of rainfall on HM, it was expected that the effects of rainfall would have been manifest through animal performance. This, however, appears not to be the case.

The other coefficients that warrant comment are those for veld condition (or the proportion of high producing grasses) and for the unpalatable grasses (Elionurus muticus and Eragrostis plana). The latter would not be consumed by cattle and yet they had a negative effect on IAP. The reason may be that they often make up a relatively large component of the swards (> 30%) and, although they are not consumed, they do occupy area that could otherwise be occupied by forage producing species. The result of their presence is therefore to limit the available food i.e. an indirect effect. Herein may also lie the reason why the high producing species have a greater negative effect on IAP than do the unpalatable species. The unpalatable grasses are not grazed and therefore have an indirect effect on IAP, whereas the high producing species have a direct effect (for reasons discussed in Chapter 10).

CHAPTER 15

A STOCKING RATE MODEL FOR THE SOUR SANDVELD

CHAPTER 15

A STOCKING RATE MODEL FOR THE SOUR SANDVELD

15.1 A DESCRIPTION OF THE STOCKING RATE MODEL FOR THE SOUR SANDVELD

The component models described in Chapters 13 and 14 were integrated to produce a stocking rate model for the Sour Sandveld, illustrated in Fig. 15.1. As for the Lowveld model, the following should be noted with respect to the layout of Fig. 15.1: some parameters (free standing) are essential in preliminary steps for determining the direct inputs (in blocks with a single outline). The direct inputs are those required for obtaining output from the models (the positions of which are indicated by blocks which are shadowed). With the herbage mass models an additional step may be useful to determine the herbage available to the grazing animal (indicated by blocks

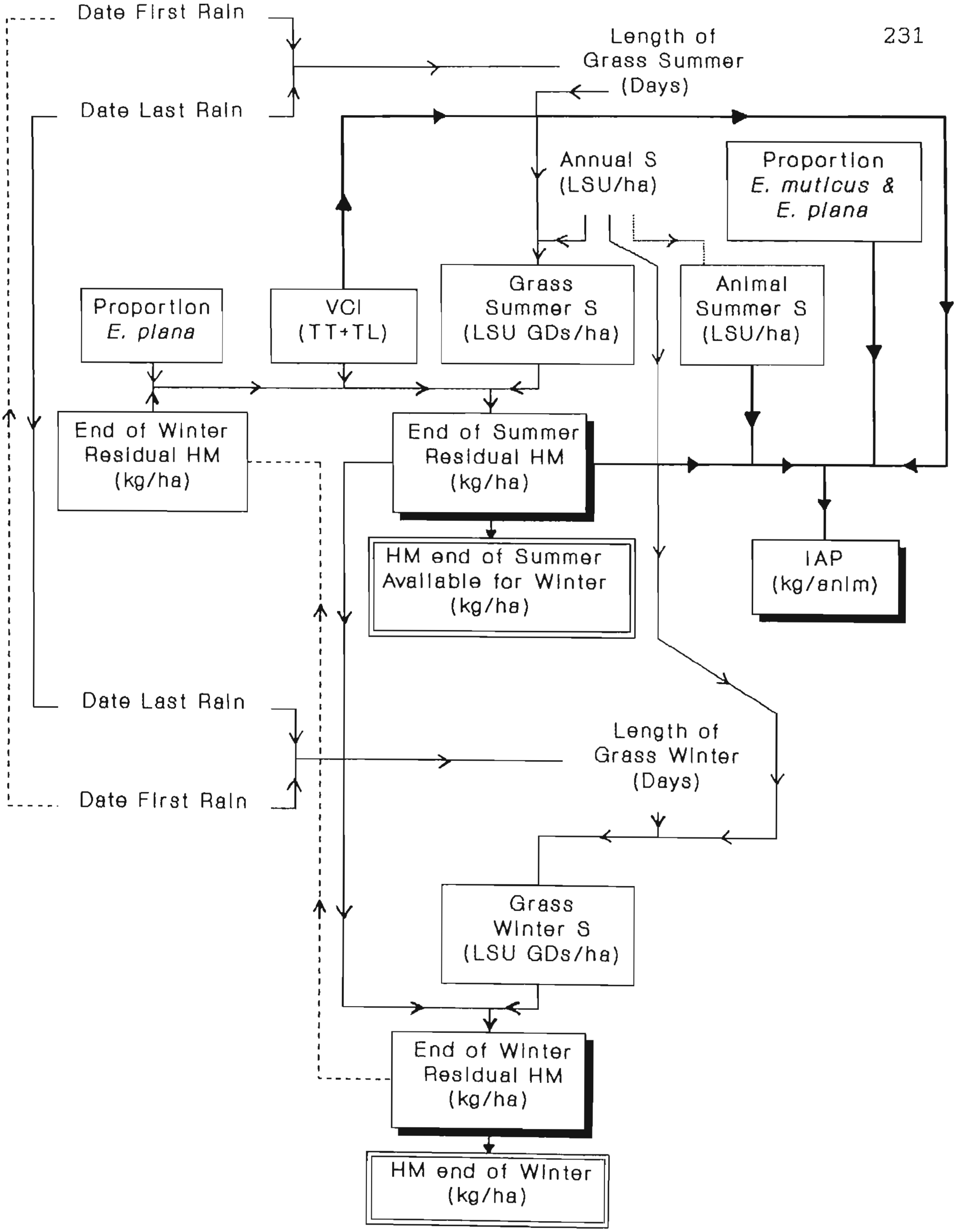


Fig. 15.1 A stocking rate model for the Sour Sandveld. The Layout is fully explained in the text.

with a double outline). The thin solid lines indicate the flow of inputs to the herbage mass models. The thick solid lines indicate the flow of inputs to the animal performance model. The finely dotted lines indicate steps where the following parameter is indirectly calculated from the preceding parameter or requires some judgement. The stippled lines indicate the required flow of information for successive iterations of the model over successive seasons (with all other inputs remaining constant).

This model may be used in both for planning and for aiding in management decisions at farm level. The applications and the suggested approaches for the use of the model in each of these applications is discussed in greater detail in the conclusion.

15.2 PRACTICAL ASPECTS ON THE CALCULATION OF PARAMETERS

The calculation of the inputs has already been described in the development of the component models. For the same reasons as for the Lowveld, some guidelines for the calculation of the inputs at farm level may be useful.

a. <u>Length of the grass summer</u>. For the same reasons as for the Tall Grassveld, should there be no clear transition between winter and summer, then the 1st September would probably be a reasonable approximation of the time when grass growth starts in response to rainfall. However, if the start of the grass summer is obvious, then the date at which the first rains fell should be used as the date of first rains. In view of the slow rates of grass growth in April, the 31st March is probably a reasonable approximation of the end of the grass summer.

b. <u>End of winter residual herbage mass (kg/ha)</u>. As with the Lowveld, it is suggested that a grazing cut-off of 4 cm be adopted (although it is recognised that this may differ with different sward conditions and for different defoliation regimes). Because of the relatively heavy stocking rates that are currently being applied in these areas, it is unlikely that there will be much residual herbage in excess of that available to animals at the end of the winter. In the absence of estimates of residual herbage mass at the end of winter using the disc meter, the following guidelines are suggested:

heavily grazed sward - 4 cm or 1667 kg/ha;
moderately grazed sward - 5 cm or 1987 kg/ha;
lightly grazed sward - 6 cm or 2308 kg/ha; and
if veld was burnt - 0 kg/ha.

Should these be underestimates, it will introduce conservatism into the model. Note that the output from the model for the previous winter could also be used as input into the model for the following summer.

However, such iteration of the model from season to season without some verification will be unwise in the application of the model. From experience, it is suggested that the end of the winter would be the easiest time to do such an evaluation in preference to the end of summer.

c. Veld condition index (VCI) and other veld condition parameters. Here two species were used in the calculation of VCI. An additional two species contributed to other veld condition parameters. The same cautions suggested for the determination of the VCI for the Lowveld should be adopted for the determination of the VCI for the Sour Sandveld (see Section 7.2).

d. Grass summer stocking rate (S) (LSU GDs/ha) for the end of summer HM component model. This is calculated from the mean annual stocking rate (Annual S (LSU/ha)). For the farm situation, LSUE should be realistically assigned to various classes of stock using the guidelines of Meissner *et al*. (1983).

e. Animal summer stocking rate (S) (LSU/ha) for the IAP component model. The same solution is suggested here as for the Lowveld Model: a guide may be obtained from the ratios of summer:mean stocking rate in Table 12.3. However, it would seem that here only one conversion factor is appropriate for calculating summer stocking rate from mean annual stocking rate i.e. 1,2.

f. End of summer residual herbage mass (kg/ha). As for the Tall Grassveld, it is suggested that the output from the summer component model be used as the input for the winter component model, particularly where the end of summer residual HM cannot be objectively determined.

g. Grass winter stocking rate (S) (LSU GDs/ha). This is calculated in the same way as the summer stocking rate i.e. from the mean annual stocking rate (Annual S (LSU/ha)).

As for the Lowveld model, the calculation of the available residual herbage mass at the end of each season is optional. The grazing cut-off suggested in Chapter 12 is 1667 kg/ha (a disc height of 4 cm). To obtain an estimate of available herbage, the estimated grazing cut-off is simply subtracted from the output of the herbage mass component models.

15.3 MODELLING STOCKING RATE FOR THE SOUR SANDVELD

A concern in presenting the results here is that rainfall was shown not to influence grass production. An explanation for this was given in Section 13.1. The application of the Sour Sandveld Model will be discussed later.

A typical scenario for the Sour Sandveld is given in Table 15.1. This scenario forms the basis of the remaining discussion in this Section in which the effects of altering the stocking rate and the length of the winter for veld in different conditions will be assessed. Some points therefore need to be noted. The stocking rate of 0,29 LSU/ha (or 3,5 ha/LSU) is probably light in comparison to currently applied stocking rates in farming situations in this area. This has, however, been used as a basis for the intermediate stocking rate because it is the stocking rate which the author feels should be an absolute maximum for this veld type. The dates for the first and last summer rains shown in Table 15.1 are typical of a "normal" year for the Sour Sandveld. No residual carry over of available herbage (above the grazing cut-off) into the summer has been assumed. Veld with a VCI of 30 is probably in relatively good condition for this veld type. The values of 5% included for Eragrostis plana and Elionurus muticus are probably lower than the average for this veld type. The HM values in the remaining tables will also be expressed as residual available herbage mass assuming a grazing cut-off of 1667 kg/ha or a disc height of 4 cm.

The effects of stocking rate and veld condition on residual available herbage mass, both at the end of winter and at the end of summer, and on individual animal performance, under

Table 15.1 A basic scenario for unburnt veld using the stocking rate model for the Sour Sandveld.

Mean annual S	(ha/LSU)	3.5
Mean annual S	(LSU/ha)	0.29
SUMMER GRASS PRODUCTION:		
First summer rain	(date)	1 Oct
Last summer rain	(date)	31 Mar
Length grass summer	(days)	181
Length grass summer	(weeks)	26
Grass summer S	(LSU GDs/ha)	52
HM (end of winter)	(kg/ha)	1667
VCI	(TT+TL)	30
Proportion EP	(%)	5
Proportion EM	(%)	5
Proportion EP+EM	(%)	10
HM (end of summer)	(kg/ha)	2939
DH Grazing cut-off	(cm)	4
HM Grazing cut-off	(kg/ha)	1667
HM (available for winter use)	(kg/ha)	1272
WINTER GRASS PRODUCTION:		
Last Summer Rain	(date)	31 Mar
First Summer Rain	(date)	1 Oct
Length grass winter	(days)	184
Length grass winter	(weeks)	26
Grass winter S	(LSU GDs/ha)	53
HM (end of summer)	(kg/ha)	2939
HM (end of winter)	(kg/ha)	2209
HM (grazing cut-off)	(kg/ha)	1667
HM (available at the end of winter)	(kg/ha)	542

DH = Disc height
EM = *Elionurus muticus*
EP = *Eragrostis plana*
HM = Herbage mass
S = Stocking rate
VCI = Veld condition index

conditions otherwise similar to those presented in Table 15.1, is shown in Table 15.2. Under these conditions residual available herbage at the end of winter really only becomes limiting under heavy stocking. Veld condition does have a major impact on the ability to overwinter cattle without additional supplementary feed. With respect to animal performance, both stocking rate and veld condition have a large effect on individual animal performance. It should be noted, however, that the positive effect attributed to lighter stocking and the negative effect attributed to improved veld condition is probably related to the quantity (and therefore also to the quality) of available forage.

The effect of a more degraded veld with higher proportions of <u>Eragrostis</u> <u>plana</u> and <u>Elionurus</u> <u>muticus</u> (an increased from 5% to 15% for both species), but having the same VCI (which would be possible), is shown in Table 15.3. The result is a higher residual available HM. However, the large negative effect of this degraded veld on individual animal performance is marked (a decrease of about 11 kg/animal/summer). It could also be expected that the winter individual animal performance in veld with large proportions of these two species would be relatively poor in relation to veld with only a small proportions because of the greater proportion of unpalatable material in the sward.

For the same reasons as for the Lowveld, the effects of a late spring is of interest. The effect of delayed spring

Table 15.2 Residual available herbage mass (HM) for unburnt veld at the end of summer and at the end of the following winter and individual animal performance (IAP) for the summer for different levels of veld condition (VCI) and stocking rate. All other conditions are the same as those in Table 15.1. A conversion factor of 1,20 was used to convert mean annual stocking rate to an animal summer stocking rate (see pages 234/235).

Mean Stocking Rate		End of Summer Residual HM (kg/ha)			
		VCI			
LSU/ha	ha/LSU	0	10	20	30
0,45	2,2	718	818	918	1018
0,40	2,5	795	895	995	1095
0,35	2,9	873	973	1073	1173
0,30	3,3	950	1050	1150	1250
0,25	4,0	1028	1128	1228	1328
0,20	5,0	1105	1205	1305	1405
0,15	6,7	1183	1283	1383	1483
		End of Winter Residual HM (kg/ha)			
0,45	2,2	0	0	0	35
0,40	2,5	0	0	93	189
0,35	2,9	55	151	248	344
0,30	3,3	210	306	402	498
0,25	4,0	364	460	556	653
0,20	5,0	519	615	711	807
0,15	6,7	673	769	865	961
Summer Stocking Rate		Summer IAP (kg/summer)			
0,54	1,9	75	62	50	37
0,48	2,1	85	73	60	48
0,42	2,4	96	83	71	58
0,36	2,8	106	94	81	68
0,30	3,3	117	104	92	79
0,24	4,2	127	115	102	89
0,18	5,6	138	125	113	100

Table 15.3 Residual available herbage mass (HM) for unburnt veld at the end of summer and at the end of the following winter and individual animal performance (IAP) for the summer for different levels of veld condition (VCI) and stocking rate. All other conditions are the same as those in Table 15.1 except the proportions of Eragrostis plana and Elionurus muticus have each been increased to 15 %. A conversion factor of 1,20 was used to convert mean annual stocking rate to an animal summer stocking rate (see pages 234/235).

Mean Stocking Rate		End of Summer Residual HM (kg/ha)			
		VCI			
LSU/ha	ha/LSU	0	10	20	30
0,45	2,2	1052	1152	1252	1352
0,40	2,5	1129	1229	1329	1429
0,35	2,9	1207	1307	1407	1507
0,30	3,3	1284	1384	1484	1584
0,25	4,0	1361	1461	1561	1661
0,20	5,0	1439	1539	1639	1739
0,15	6,7	1516	1616	1716	1816
		End of Winter Residual HM (kg/ha)			
0,45	2,2	67	163	259	355
0,40	2,5	222	318	414	510
0,35	2,9	376	472	568	664
0,30	3,3	531	627	723	819
0,25	4,0	685	781	877	973
0,20	5,0	839	935	1032	1128
0,15	6,7	994	1090	1186	1282
Summer Stocking Rate		Summer IAP (kg/summer)			
0,54	1,9	64	52	39	26
0,48	2,1	75	62	49	37
0,42	2,4	85	73	60	47
0,36	2,8	96	83	70	58
0,30	3,3	106	93	81	68
0,24	4,2	117	104	91	79
0,18	5,6	127	114	102	89

rains from the 1st October to 15th November is shown in Table 15.4 under conditions otherwise similar to those in Table 15.2. The ability to overwinter animals is greatly reduced for veld in all condition classes. However, at stocking rates lighter than the moderate stocking rate (lighter than 0,36 LSU/ha), it should be possible to overwinter cattle without having to buy additional supplementary feed.

The most striking feature of the data from this veld type in relation to the other two, is the low potential of the veld for animal production, even at low stocking rates. For example, the expected IAP at a stocking rate of about 5 ha/LSU in the Lowveld would be about 200 kg/animal/summer (for an intermediate length summer) while in the Sour Sandveld the maximum one could expect is about 130 kg/animal/summer. Similarly, the expected IAP at a stocking rate of about 3.5 ha/LSU in the Tall Grassveld would be about 130 kg/animal/summer while in the Sour Sandveld one would expect about 100 kg/animal/summer.

Table 15.4 Residual available herbage mass (HM) for unburnt veld at the end of summer and at the end of the following winter and individual animal performance (IAP) for the summer for different levels of veld condition (VCI) and stocking rate. All other conditions are the same as those in Table 15.1 except the date of the first summer rain at the end of the winter which has been delayed to 15 November. A conversion factor of 1,20 was used to convert mean annual stocking rate to an animal summer stocking rate (see pages 234/235).

Mean Stocking Rate		End of Summer Residual HM (kg/ha)			
		VCI			
LSU/ha	ha/LSU	0	10	20	30
0,45	2,2	718	818	918	1018
0,40	2,5	795	895	995	1095
0,35	2,9	873	973	1073	1173
0,30	3,3	950	1050	1150	1250
0,25	4,0	1028	1128	1228	1328
0,20	5,0	1105	1205	1305	1405
0,15	6,7	1183	1283	1383	1483
		End of Winter Residual HM (kg/ha)			
0,45	2,2	0	0	0	0
0,40	2,5	0	0	0	33
0,35	2,9	0	14	111	207
0,30	3,3	92	188	285	381
0,25	4,0	266	363	459	555
0,20	5,0	440	537	633	729
0,15	6,7	615	711	807	903
Summer Stocking Rate		Summer IAP (kg/summer)			
0,54	1,9	75	62	50	37
0,48	2,1	85	73	60	48
0,42	2,4	96	83	71	58
0,36	2,8	106	94	81	68
0,30	3,3	117	104	92	79
0,24	4,2	127	115	102	89
0,18	5,6	138	125	113	100

CONCLUSION

The objective of this dissertation was to develop stocking rate models. Clearly these models could be used by advisors and managers as a basis for assessing the potential and comparing these three veld types and to conduct economic and risk analyses. Such analyses would on their own be an enormous task and will therefore not be attempted in this dissertation. It may in any case be prudent to delay such a detailed study until refined models are developed which include data from several subsequent seasons. However, some guidelines and cautions on their use for this purpose will be outlined.

The models may be used for two specific purposes.

a. Planning. Different environmental and site specific scenarios may be modelled, either at a regional or farm scale, to assist in long-term decisions on stocking rate, the requirement for fodder banks and to conduct economic and risk analyses.

b. Management. The effects of a specific set of conditions may be modelled, or the conditions of a particular season may be modelled as the year progresses, either on a farm, system or camp scale, to assist in short-term decisions on stocking rate and feed requirements.

There are three categories of variable in these models.

a. Variables over which the manager will have little control, for example rainfall and, at least in the short-term, veld condition. Rainfall cannot be predicted. Veld condition can at least be measured.

b. Variables over which the manager will have a fairly large degree of control, for example stocking rate.

c. Variables over which the manager has only partial control because variables in both the above categories influence them. For example, the residual HM which is carried forward from one season to the next can only be partially influenced by the manager through adjusting stocking rate.

In planning, central to the use of all the models will be the uncertainty attached to the parameters over which the manager has no control, and in particular rainfall, which, in addition, cannot be predicted. The two questions which will always remain unanswered with respect to rainfall are "How does one know how much rain will occur during the grass summer?" and "How does one know when the first and last rain of the summer will fall?" The suggestion for planning is to use long-term rainfall records and attach probabilities and norms to these parameters.

In management the following approach is suggested: the relevant model should be run at the end of March. The date of the first fall of the summer would be determined from the rainfall records for that season. The date of the last fall of rain before the 31st of March would give a very close approximation of the length of the grass summer. The total summer rainfall could then be determined. For the Lowveld, the length of the animal summer, required for the animal performance component model, can be determined from the length of the grass summer. Thus, at this early stage in the season it would be possible to obtain a fairly reasonable assessment of the available forage and animal mass gains over the summer. With this information it would be possible to formulate management strategies for the winter. For example, the amount of supplementary feed which may be required, the extent to which stock reduction may be necessary or the extent to which burning may be necessary in the next spring could all be determined. Animals would continue to gain mass at least until the end of May in the Lowveld and at least until the middle of May in the Tall Grassveld and Sour Sandveld. This would allow time to develop a feeding strategy before stock start to lose mass and, if stock is to be reduced, a marketing strategy which may include a finishing phase. Particularly in the Lowveld, should rain fall after the applicable model has been run, the inputs could be revised and the situation reassessed.

The possible scenarios of practical interest that could be modelled are endless. Only a limited number of scenarios of more general interest were modelled. These could be used as guides should it not be possible to use the appropriate model in practice.

Caution should always be exercised in using models to extrapolate beyond the limits of the data used in the development of the model. In this some liberty has, however, been taken for two situations in particular.

a. Dry seasons in the Tall Grassveld. The range of summer rainfall during the seasons over which the data was collected ranged from 567 mm to 1152 mm. Caution should therefore be excercised in using the Tall Grassveld Model for planning for dry seasons (<500 mm).

b. Veld in very good condition in the Lowveld. The highest VCI was 52. Though the indications are that VCI is very strongly correlated with herbage production, caution should still be exercised in using the models in situations where the VCI is greater than 60.

Caution should also always be exercised in using models in situations where the conditions are similar to those under which the data which were used to develop the models were collected. The following cautionary comments should therefore be heeded with respect to the different models.

a. The Lowveld Stocking Rate Model. The model was developed from data collected in the drier region of the Lowveld. Thus it is felt that application should be limited to the Arid Lowveld of Natal and to the drier parts of the Lowveld in Natal. To apply the models to the more moist parts, for example in areas with a mean annual rainfall in excess of 700 mm, would be foolish.

b. The Tall Grassveld Stocking Rate Model. Of all the models, it is this one which will have widest application within the veld type for which it was developed. However, the model should be used with caution in the more moist areas (with mean annual rainfall in excess of 850 mm).

c. <u>The Sour Sandveld Stocking Rate Model</u>. The fact that rainfall was shown not to affect herbage production places some doubt on the wider application of this model within the veld type. However, for reasons given, it may well be that rainfall has little influence on herbage production on the poor sandy soils typical of this area. Thus it is suggested that application of at least the residual herbage mass component models be confined to typical Sour Sandveld. The animal performance component model could probably be applied more widely because these levels of performance appear to be within the range of norms for this veld type. Once more data become available it will probably be worth developing seperate models from data collected at the respective sites rather than maintain a combined model.

Many outliers of the Tall Grassveld occur scattered throughout the Sour Sandveld (Acocks, 1975). These are associated particularly with dolerite outcrops. In the absence of an alternative, dare it be suggested that the Tall Grassveld Stocking Rate Model could be applied to these areas, which are in some cases probably strongly transitional between

Tall Grassveld and Sour Sandveld. Should the Tall Grassveld Stocking Rate Model be applied to these areas, it is felt that an adjustment to stocking rate should be made, recognising that the production potential of these areas is probably lower than that of typical Tall Grassveld. For example, should a particular stocking rate be decided on as a result of the model, a downward adjustment in stocking rate could be made by adding arbitrarily, for example, 1 ha/LSU to the proposed stocking rate.

Possibly the greatest limitation of these models is that they do not account for the carry-over effects from one season to the next and therefore particularly the long-term effect of stocking rate on veld condition. Because of this, it is suggested that for the moment veld should be sufficiently leniently stocked so that shortages of food should not occur at the end of the winter, even in relatively dry years. This should ensure at least some lenience in the utilisation of the veld in the summer. This, one hopes, would result in the maintenance or even the improvement in the vigour of the veld and therefore also in the maintenance of or the improvement in veld condition.

The models have not been corroborated and it is unlikely that they will be. There will therefore always be some uncertainty associated with their use. It is hoped, however, that with the additional data that is still currently being collected it will be possible to revise and refine these initial models. Nonetheless, it is felt that these initial models could be of great value to veld managers in these areas.

Veld management (including the conversion of veld to livestock products) will remain part art and part science. No model will ever be perfect. The manager will always have to have his "eyes and ears to the ground" to ensure complete success. These models, therefore, can only provide a scientific basis from which to work and improve the art of veld management.

REFERENCES

Acocks, J.P.H., 1975. Veld Types of South Africa. Botanical Research Institute, Dept. Agric. Tech. Services.

Anon, 1981. Grazing capacity in Natal. Natal Agricultural Region Pasture Section in conjunction with the Extension Officer at Kokstad.

Anon, 1987. Computing Centre for Water Research, University of Natal, Pietermaritzburg.

Barnes, D.L. and McNeill, Lindsay, 1978. Rainfall variability and animal production in the semi-arid savanna of southern Africa. Proc. Grassld Soc. Sth. Afr. 13: 59-63.

Booysen, P. de V., 1967. Grazing and grazing management terminology in Southern Africa. Proc. Grassld Soc. Sth. Afr. 8: 45-57.

Bransby D.I., 1981. Forage quality. In: Tainton, N.M. and Booysen, P. de V. (Eds). Veld and Pasture Mangement in South Africa. Shuter and Shooter, Pietermaritzburg.

Bransby, D.I., 1982. The use of covariance analysis to compare derived linear regressions in stocking rate trials. Proc. Grassld Soc. sth. Afr. 17: 38-40.

Bransby, D.I., 1984. A model for predicting livemass gain from stocking rate and annual rainfall. J. Grassl. Soc. Sth. Afr. 1(2): 22-26.

Bransby, D.I. & Tainton, N.M., 1977. The disc pasture meter: possible applications in grazing management. Proc. Grassld Soc. Sth. Afr. 12: 115-118.

Danckwerts, J. E., 1989. Animal performance. In: Dankwerts, J.E. and Teague, W.R. (Eds). Veld Management in the Eastern Cape. Department of Agriculture and Water Supply, South Africa.

Danckwerts, J.E. and King, P.G., 1984. Conservative stocking or maximum profit: a grazing management dilemma. J. Grassl. Soc. sth. Afr. 1(4): 25-28.

Draper, N. and Smith, H., 1981. Applied regression analysis, 2nd ed.. Wiley and Sons, New York.

Edwards, D., 1974. Survey to determine the adequacy of existing conserved areas in relation to vegetation types. Koedoe 17: 2-37.

Edwards, P.J., 1981. Grazing Management. In: Tainton, N.M. and Booysen, P. de V. (Eds). Veld and Pasture Mangement in South Africa. Shuter and Shooter, Pietermaritzburg.

Gammon, D.M., 1983. Stocking rate and drought considerartions. Zimbabwe agric. J. 80(5): 183-185.

Heard, C.A.H., Tainton, N.M., Clayton, J. and Hardy, M.B., 1986. A comparison of five methods for assessing veld condition in the Natal Midlands. J. Grassl. Soc. Sth. Afr. 3: 70-76.

Jones, R.J. and Sandland, R.L., 1974. The relation between animal gain and stocking rate: derivation: of the relation from results of grazing trials. J. Agric. Sci. Camb. 83: 123-128.

Karnezos, T.P., Tainton, N.M. and Bransby, D.I., 1988. A mathematical model used to describe animal performance on Kikuyu and Coastcross II pastures. J. Grassl. Soc. Sth. Afr. 5(1): 38-41.

Lishman, A.W., pers. comm.. Dept. Animal Science, University of Natal, P.O. Box 375, Pietermaritzburg, 3200.

Louw, B.P., pers. comm.. Deptartment of Agriculture, P.Bag X9059, Pietermaritzburg, 3200.

Meaker, H.J., pers. comm.. Stockowners Cooperative (Pty) Ltd, P.O. Box 199, Dundee, 3000.

Meaker, H.J., 1989. Vleisbeestipes en produksiestelsels. Red Meat, August, 1989.

Meissner, H.H., Hofmeyr, H.S., van Rensburg, W.J.J. & Pienaar, J.P., 1983. Classification of livestock for realistic prediction of substitution values in terms of a biologically defined Large Stock Unit. Tech. Comm. No. 175, Dept of Agriculture, South Africa.

Moll, E.J., 1981. Trees of Natal. Eco-lab Trust Fund, University of Cape Town, Cape Town.

Philips, J., 1969. The Agricultural and related development of the Tugela Basin and its influent surrounds. Natal Town and Regional Planning Report, Vol 19. Final report published in 1973.

Riewe, M.E., 1961. Use of the relationship of stocking rate to gain of cattle in an experimental design for grazing trials. Agron. J. 53: 309-313.

Rutherford, M.C., 1978. Primary production ecology in southern Africa. In: Werger, M.J.A. (Ed). Biogeography and Ecology of Southern Africa. Dr W. Junk Publishers, The Hague.

Schulze, R.E., 1982. Agrohydrology and -climatology of Natal. Agric. Catchments Res. Unit Rep. no. 14, Nov 1982.

Tainton, N.M., 1977. Grazing management and the grass/bush balance. Proc. Symp. on Veld and Bush Management for Beef and Game Production. Hlabisa Soil Conservation Committee, October 1977.

Tainton, N.M., pers. comm.. Dept. Grassland Science, University of Natal, P.O. Box 375, Pietermaritzburg, 3200.

Turner, J.R. 1988. Towards the development of a grazing capacity model for the drier grazing areas of Natal. M.Sc. Thesis, University of Natal, Pietermaritzburg.

Turner, J.R., 1988b. Carrying capacity of veld: The concept of carrying capacity and factos affecting it. M.Sc. Seminar no. 1. Department of Grassland Science, University of Natal.

Turner, J.R., 1988c. Carrying capacity of veld: Approaches and methods for estimating carrying capacity. M.Sc. Seminar no. 2. Department of Grassland Science, University of Natal.

van Niekerk, A., Hardy, M.B., Mappledoram, B.D. and Lesch, S.F., 1984. The effect of stocking rate and lick supplementation on the performance of lactating beef cows and its impact on Highland Sourveld. J. Grassl. Soc. Sth. Afr. 1(2): 18-21.

APPENDICES

APPENDIX 1

MATERIALS AND METHODS

1 INTRODUCTION

Grazing trials on the scale of this project could be considered for these areas only if they could be run co-operatively with farmers. It will be noticed that strong consideration had to be given to this in the experimental design. It was therefore also not always possible to follow and implement the intended design.

2 VELD TYPES

The three veld types (Acocks, 1975) covering the most extensive areas of the drier grazing regions of Natal were selected for implementing grazing trials. The veld types that were selected (Fig. 1) are Lowveld (10), Southern Tall Grassveld (65) (referred to as Tall Grassveld) and Natal Sour Sandveld (66) (referred to as Sour Sandveld).

The veld types classification (Acocks, 1975) was preferred despite the popular use of the bioclimatic group classification (Fig. 2) (Philips, 1969) in Natal. The Tall Grassveld and the Sour Sandveld veld types both fall largely into bioclimatic group 8, the Upland (drier). Also, the Valley Bushveld (23) and the Lowveld (10) both fall largely into bioclimatic group 10, the Interior Lowland. The reason for reverting to the veld types classification, especially for the areas under consideration, is that the veld types

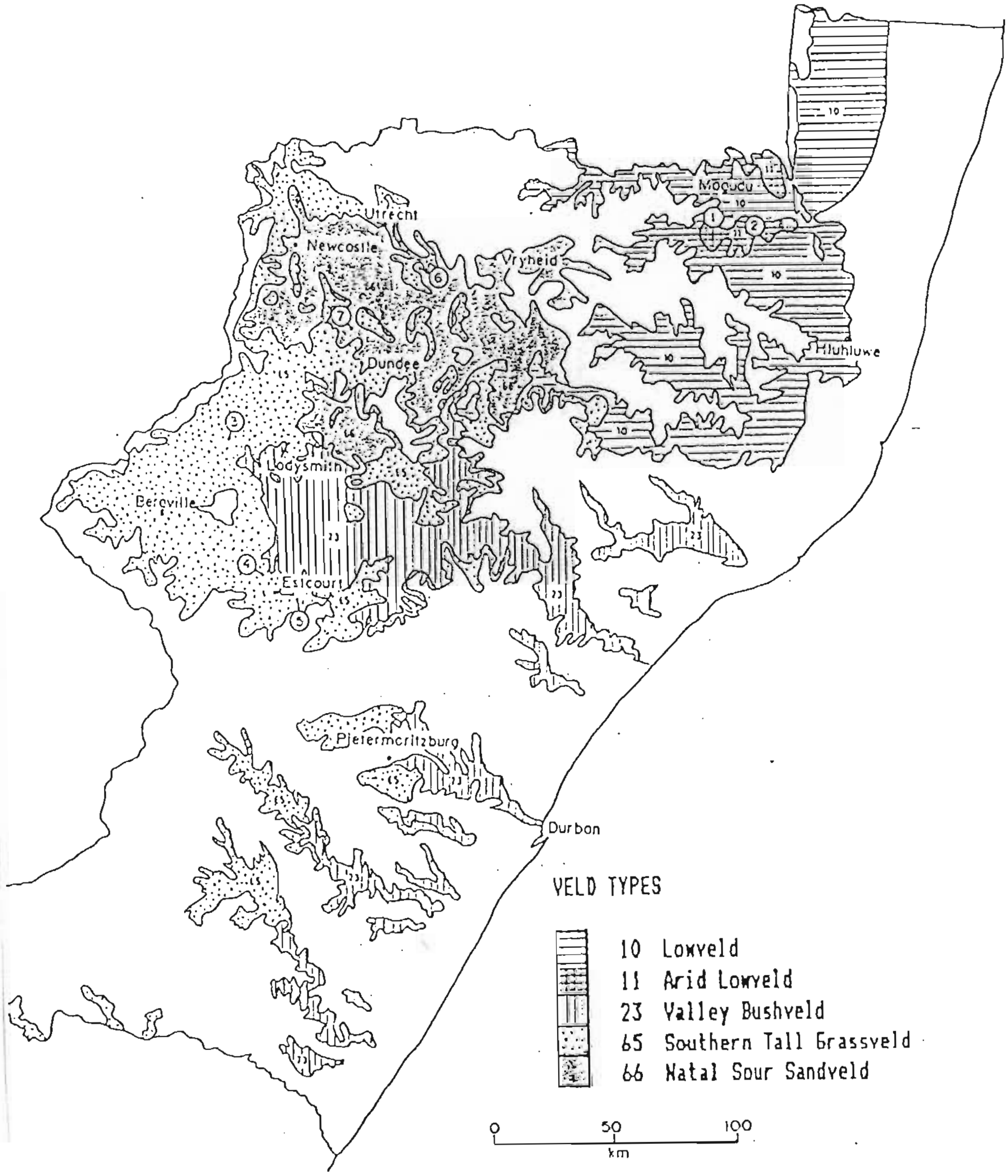


Fig. 1 of Appendix 1
The extent of the veld types under study in Natal showing also the location of sites (adapted from Acocks, 1975).

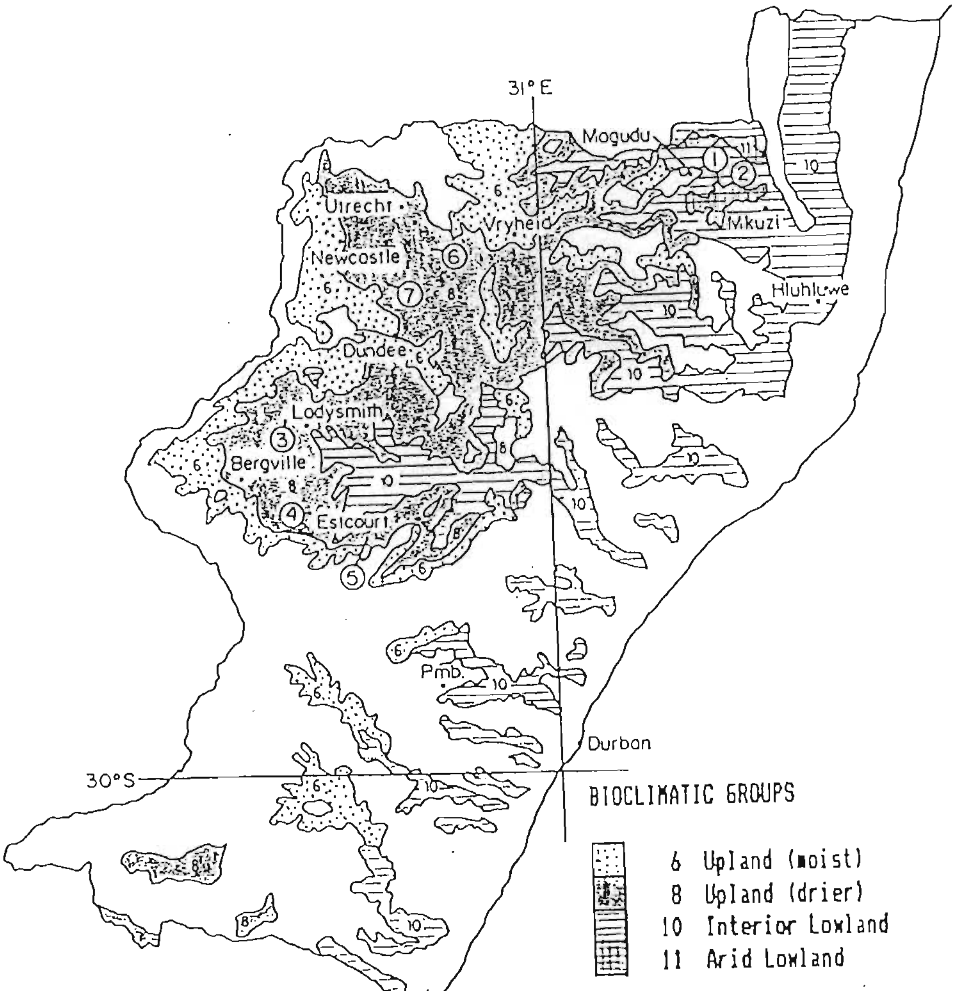


Fig. 2 of Appendix 1
The bioclimatic regions of Natal showing also the location of sites (adapted from Tainton, Bransby & Booysen, 1976).

classification is a better reflection of the potential of veld for animal production than the bioclimatic groups classification, the latter being a better reflection of cropping potential (Tainton, pers. comm.).

3 SELECTION AND LOCATION OF SITES

Before the sites could be selected, there had to be criteria for selection. The main considerations were 1) the achievement of a suitable experimental design and 2) the establishment and management of the sites. Experimental criteria were:

a. three sites varying in veld condition from "excellent", "moderate" to "poor" were required for each veld type;

b. the site had to be "typical" of the veld type or at least "representative" of large areas of veld in the veld type; and

c. the area had to be sufficiently large.

Determination of the areas required depended on three factors.

a. Class of animal. Weaners or yearlings were to be used in the trials.

b. Number of animals per treatment. 10 animals were to be used per stocking rate treatment.

c. Stocking rates that were to be applied. Use was made of the estimates of current average grazing capacity for the bioclimatic regions of Natal (Anon, 1981) as guides for determining stocking rate treatments. However, in view of both farmer opinion and the earlier discussion on veld types and bioclimatic groups, the value for the Tall Grassveld was changed from the current recommendation to what was considered more realistic for this veld type, its potential for animal production being higher than that of the Sour Sandveld. In each veld type, the moderate treatment would approximate the currently recommended average grazing capacity while the heavy and light stocking rate treatments would be approximately 30% heavier and lighter respectively.

The tables of Meissner et al. (1983) were used to estimate the animal unit equivalence (AUE) of the animals. It was assumed that animals would average 300 kg for the grazing season and that they would, on average, gain 500 g/day. Such an animal would equal 0,78 AUE. On these assumptions, the stocking rates that would have been achieved taking the above assumptions into account are indicated in Table 1. Areas required for each site were, therefore, 140 ha for the Lowveld, 60 ha for the Tall Grassveld and 80 ha for the Sour Sandveld.

Certain requirements had to be met by farmers for them to be able to participate.

a. A suitable area had to be provided on which the trials could be run (for which no compensation would be given), criteria for which were

   1) the available area had to be sufficiently large,

   2) the area had to be relatively uniform in appearance, although this was difficult in view of the large areas required,

   3) the veld had to be suitable i.e. in appropriate condition,

   4) the area had to be within reasonable proximity to handling facilities,

Table 1 of Appendix 1
Stocking rates aimed at for each of the three veld types in relation to the currently recommended average grazing capacity (CAGC). (L, M and H are the light, moderate and heavy stocking rate treatments respectively. LV, TG and SS are the Lowveld, Tall Grassveld and Sour Sandveld respectively.)

Veld Type	CAGC (ha/AU)	Stocking Rate					
		L (ha/LSU)	M (ha/LSU)	H (ha/LSU)	L (LSU/ha)	M (LSU/ha)	H (LSU/ha)
LV	7,0	10,0	7,0	5,6	0,10	0,14	0,18
TG	3,9	3,6	2,5	1,9	0,28	0,40	0,52
SS	3,9	4,9	3,5	2,6	0,20	0,29	0,38

5) the area had to be reasonably accessible,

6) water had to be available, and

7) the area had to be situated so that minimum inconvenience would be caused to the farmer.

b. Animals (thirty in number, either weaners or yearlings) had to be provided for use on the trials (also for which no compensation would be given).

c. The researcher had to be allowed to feed licks of his choice so that the same licks could be fed, at least within the same veld type.

d. The farmer would have to continue to manage the animals with respect to dipping and inoculation.

e. As far as possible, the farmer should be prepared to provide some assistance with labour both in establishing the trials and in the subsequent running of the trials.

There were two major considerations with respect to management.

a. The situation of the site in relation to dangers such as theft and fire.

b. The enthusiasm of the farmer for rendering assistance in the running of the trials and during crises.

The availability of suitable sites was limited by four major factors.

a. The extent to which farmers in these veld types could be reached in the limited time available. Many farmers who could potentially have made offers were not reached. (Many have made offers subsequently, particularly in the Sour Sandveld, possibly as a result of growing enthusiasm for the trials as they have begun to show their potential value).

b. The number of farmers who were prepared to accept the requirements and have such an "inconvenience" (depending on how such a trial is viewed by the individual) for the four years the trials are to run.

c. The suitability of the farming operation. Since yearlings are being used, the trials are most suited to systems where cattle are marketed at two years or older. However, farmers had the option to either offer the use of replacement heifers or to specially keep a group of oxen back for use in the trials.

d. The number of areas on any particular farm which were suitable. Most farms had very few areas which could meet all the requirements.

From the suitable areas offered, sites for the establishment of the grazing trials were subjectively selected. The location of the sites in relation to the veld types is indicated in Fig. 1 and in relation to bioclimatic groups in Fig. 2. The co-ordinates and altitude of each site are given in Table 2.

In the Lowveld two sites were selected. Site 1, at the time considered to be in moderate condition, is located on the farm Llanwarne and Site 2, considered at the time to be in poor condition, on the farm Dordrecht. They are situated almost adjacent to one another. Both are representative of large areas of this veld type although there is fairly extensive erosion on Site 2.

In the Tall Grassveld four sites were selected, one of which had to be withdrawn soon after the start of the trials. Site 3, considered at the time to be in excellent condition, is located on the farm Walkershoek. This site is situated on a dolerite ridge and is representative of fairly large areas of the Tall Grassveld. Site 4, considered at the time to be in good condition, is located on the farm Heavitree. It is the most representative and typical of large areas of Tall Grassveld. Site 5, considered to be in moderate condition at

Table 2 of Appendix 1
The co-ordinates and altitude of each site in each veld type. (LV, TG and SS are the Lowveld, Tall Grassveld and Sour Sandveld respectively.)

Veld Type	Site	Co-ordinates		Altitude (m)
		Latitude	Longitude	
LV	1 2	27 35'S 27 36'S	31 45'E 31 46'E	320 320
TG	3 4 5	28 28'S 28 56'S 29 03'S	29 41'E 29 49'E 29 58'E	1200 1120 1250
SS	6 7	27 51'S 28 01'S	30 29'E 30 11'E	1280 1300

the time, is located on the farm Ntunda. It is also fairly representative of the veld type.

In the Sour Sandveld an unexpected situation arose. Only two sites were offered. Neither site was "typical". On reappraisal of the situation, it was established that much of the area had been ploughed in the past and that many of the enterprises have sheep. Therefore few farms in this area were suitable for veld work using cattle. It was nonetheless decided that both the sites offered should be used. Site 6, considered to be in moderate condition, is located on the farm Balmoral. It is also situated on a dolerite ridge, and its use was justified on the basis that it is representative of fairly large areas in this region. Site 7, considered to be in moderate to poor condition at the time, is situated on the farm Gowan Brae. It is also not entirely "typical". Half of the area spans typical Sour Sandveld and half lies on the base of a dolerite ridge. Although these two sites are similar in veld condition, they are different in "type".

The subjective veld condition rating of the sites is shown in Table 3.

Sites 1, 2 and 4 are not the size originally hoped for. The number of animals being used on these three sites was therefore reduced. The area of each site, the number of animals being used per treatment and the area allocated to each treatment, is shown in Table 4.

Table 3 of Appendix 1
The subjective allocation of sites to veld condition classes for each veld type. (LV, TG and SS are the Lowveld, Tall Grassveld and Sour Sandveld respectively.)

Veld Condition Classes	Veld Type		
	LV	TG	SS
Very poor	–	–	–
Poor	Site 2	–	–
Moderate to poor	–	Site 5	Site 7
Moderate	Site 1	–	Site 6
Moderate to good	–	–	–
Good	–	Site 4	–
Excellent	–	Site 3	–

Table 4 of Appendix 1
The total area of each site, the area of each treatment at each site and the number of animals used per site and per treatment. (L, M and H are the light, moderate and heavy stocking rate treatments respectively. LV, TG and SS are the Lowveld, Tall Grassveld and Sour Sandveld respectively.)

Veld Type	Site	Area (ha)				No. of Animals			
		Total	L	M	H	Total	L	M	H
LV	1	114,7	51,3	34,2	29,2	25	8	8	9
	2	90,5	36,6	28,6	25,3	19	6	6	7
TG	3	60,5	25,3	20,1	15,1	30	10	10	10
	4	47,0	20,3	15,5	11,2	24	8	8	8
	5	60,9	25,4	20,2	15,3	30	10	10	10
SS	6	80,0	35,1	25,3	19,6	30	10	10	10
	7	79,4	34,7	25,0	19,7	30	10	10	10
Total	7	533,0	228,7	168,9	135,4	188	62	62	64

4 PRETREATMENT OF THE EXPERIMENTAL SITES

The pretreatment for the sites situated in the Lowveld was a heavy winter grazing. There was therefore little residual herbage carried over into the first season the trials were run.

For the sites situated in the Tall Grassveld and the Sour Sandveld a spring burn after the first spring rains was applied. No residual herbage was therefore carried over into the first season the trials were run.

5 GRAZING MANAGEMENT

The original intention was to apply continuous grazing to all the sites, since the results would have been largely free of management influences imposed by the use of rotational grazing systems. However, although not related directly to the research, an important objective of this research is that the trials gain credibility among the farmers of these regions so that the recommendations arising from it will be accepted and ultimately be applied.

Objections to the use of continuous grazing from farmers in these regions therefore resulted in the decision to use some form of rotational grazing. However, there were restrictions on implementing rotational grazing systems, including limited funding and because the trials were to be spread throughout a large area so that control would be difficult. Despite this, equitable systems were decided on in conjunction with farmers, researchers and extension personnel.

5.1 LOWVELD

In the Lowveld a two camp system was implemented (Fig. 3). The camps would receive an autumn rest in alternate years. The autumn rest for a particular camp would coincide with the season in which spring and early summer grazing was applied. The utilisation outside of the active growing season would be shared between camps so that maximum benefit might be obtained from them during this time. The period of stay in the Lowveld sites depends on the season and it is therefore variable.

Animals were introduced onto the sites on 17th December 1986 when it was considered that there was sufficient available herbage. The spring was possibly slightly later than is usual for this area.

A phosphate lick is fed only in the winter. The reason for this is that lick intake is very low in this area, even in the winter months.

CAMP NO	YEAR			
	1	2	3	4
X1	S	A	S	A
X2	A	S	A	S

Fig. 3 of Appendix 1
The two camp system implemented on sites situated in the Lowveld. X1 and X2 signify the two camps allocated to a particular stocking rate treatment. Season of grazing of a camp in successive years is designated by S and A (spring and autumn).

5.2 TALL GRASSVELD AND SOUR SANDVELD

In both the Tall Grassveld and the Sour Sandveld four camp systems were implemented (Fig. 4). Three camps would be utilised during the spring, summer and autumn (approximately 9 months from September to May). The fourth would be rested for this period and utilised for winter grazing. However, in an unfavourable season, it could be incorporated into the rotation during the summer for one grazing rotation. Also, if a season proved particularly favourable, the rested camp need not be used, even in the winter. The two camps to remain in the grazing cycle the following year (for example camps X1 and X2 from year 1 to year 2) would, if necessary, be used in winter so that excessive residual herbage would not be carried into the next season. The camp rested for the summer (R) would be burnt, if necessary, in the spring before being included as the first camp (G1) in the rotation for the next growing period.

The third camp of the camps grazed during the previous growing period (G3) would be put out to rest the following summer. However, this camp would be used once in the spring to coincide, if possible, with the initial spring flush of the veld, so that the camp which would otherwise have been used first would have some relief during that initial growing period. The effect of this would be to delay the grazing rotation by one period of stay (3 weeks).

CAMP NO	YEAR			
	1	2	3	4
X1	G1	G2	G3	R
X2	G2	G3	R	G1
X3	G3	R	G1	G2
X4	R	G1	G2	G3

Fig. 4 of Appendix 1
The four camp rotational grazing system implemented on the sites situated in the Tall Grassveld and the Sour Sandveld. X1, X2, X3 and X4 signify the camps allocated to a particular stocking rate treatment. G1, G2 and G3 designate the order in which camps will be grazed in any particular year. R designates the camp that would be rested for winter grazing.

Animals were introduced onto Sites 3, 4 and 5 on the 19th, 20th and 21st November respectively, and onto Sites 6 and 7 on the 24th and 25th November respectively, when it was considered that there was sufficient available herbage. This was possibly a few weeks later than is usual for these areas, even on burned veld.

The period of stay is three weeks and the period of absence six weeks. The movement of animals from one camp to another coincides with weighing of the animals.

Winter lick will be made available _ad lib_. from about the 20th March to about the 20th October, a common practise in these areas. A winter lick, which is widely used in these areas, is being used at all the sites in these two veld types. Intake is being monitored. A palatable summer lick containing phosphates is made available for the remainder of the year.

6 LAYOUT OF THE GRAZING TRIALS

Each site was divided into camps to permit three stocking rates to be applied. The layout of the grazing trials was largely influenced by the site characteristics, especially terrain. The sites in the Lowveld were stratified into two, and the sites in the Tall Grassveld and Sour Sandveld into four equal areas, to coincide with the grazing system to be applied. This stratification was based on aspect, slope or location on the slope, depending on the relevant factors applicable to the specific site. Each stratified area was then divided into camps of different sizes so that the different stocking rates would be achieved. The allocation of the positions of the treatments within the stratified areas was random. Each stratified area was designated a number, and the camps within each such area then formed a group of camps. In Addendum 1 to Appendix 1 the layout of each site, with the numbers and the areas of each camp, is given. The areas allocated to each treatment within sites is also indicated in Table 4.

In the Lowveld difficulty was encountered in measuring and marking the sites. After the bushlines were cut they were remeasured and the areas recalculated. There is thus the anomaly that there is always one extra animal for the heavy treatment on those two sites so that the range of stocking rates required will be obtained.

7 VELD SPECIES COMPOSITION

It was decided that the diagonal transects across camps should be used for collecting species composition data for each camp. For long narrow camps the longest transect would be used along which 300 points would be recorded. For the remainder two transects each of 150 points would be used in each camp. This would result in 300 points being taken in each camp.

The use of permanent 30m X 30m quadrats was also considered. However, it was felt that there was a danger that selective grazing would influence results unless several quadrats per camp were used. This would also have necessitated an increase in sampling intensity to such an extent that it would have made the use of this method untenable.

Only the nearest established plant to each point position was recorded. However, if the distance to the nearest plant exceeded 30 cm, it was recorded as unallocated bare ground. The data were collected serially. Veld condition assessments were undertaken in the first half of January 1987.

8 PRODUCTION AND AVAILABILITY OF HERBAGE

The disc meter (Bransby and Tainton, 1977) was used for estimating herbage mass. Estimates are being made in 72 camps at three week intervals so that other methods such as quadrat sampling or strip sampling could not even be considered. Fifty readings were taken in each camp at three week intervals to coincide with the grazing rotation.

When the disc meter was calibrated, it was considered unnecessary to calibrate it for each site. Rather, calibration was across sites but for both the grazed and the rested veld separately. However, sampling for the calibrations was done equally across sites in each veld type such that an equal number of samples was obtained from each site.

For the first two seasons, calibration was required for only two conditions - grazed and rested veld, burnt in the first season and unburnt in the second season. In the third season calibration became impossible because there was both burnt and unburnt veld and both rested and grazed veld for each of the previous two conditions i.e. four conditions for which calibration would have been required. This made the logistics of calibrating the disc meter impossible.

During the first two seasons, the disc meter was calibrated at nine week intervals. At least forty five calibration samples were taken in each of the rested and the grazed veld each time the disc meter was calibrated.

In calibrating the disc meter, the sampled areas were clipped so that only the core of the crown of the grasses remained. The samples were sun dried. At the end of the sampling period, they were oven dried at 60 °C for 48 hours before they were weighed.

9 EXPERIMENTAL ANIMALS AND ANIMAL PERFORMANCE

Weaners or yearlings are being used in the trials. These animals would be at a stage of growth where maximum protein growth and least fat deposition occurs. This would reduce confounding in the interpretation of mass gains (Louw, pers. comm.). It was not feasible, however, to obtain contemporary animals from one source. Although this may have been desirable from the point of view of uniformity, it could be argued that this advantage of uniformity would be partially offset by the use of adapted animals from each of the farms (Lishman, pers. comm.).

The management and cost advantages of using weaners or yearlings rather than breeding stock in grazing trials are numerous. In particular, an important advantage favouring the use of weaners or yearlings in these trials, is that it would be least disruptive to the farming operation on the farms where trials would be established.

The animals are run on the sites for one year before they are replaced. The option was given to farmers to replace animals with a new group either at the beginning of winter (about June) or at the beginning of spring (about September). The latter option has been exercised at three sites.

It was thought that the use of females in these trials would not have adverse effects on the results. This would, however, depend on heifers not falling pregnant during the time that they were being used for the trials. The option was therefore given to farmers to offer the use of replacement heifers.

No standard pretreatment could be given to the animals used in the trials. Animals are dosed when they are first put onto the sites and then twice during the summer.

Animals are being weighed every three weeks. They are penned for the night before they are weighed.

10 RAINFALL

The mean annual precipitation of Natal was mapped by Schulze (1982) (Fig. 5). Long term rainfall records for the sites were not available except for Site 4. Mean annual rainfall for each of the sites was therefore estimated from long term rainfall data (Anon, 1987) from weather stations situated within a radius of 8' (approximately 10 km) of each site. Sites within veld types probably have similar mean annual rainfall except for Site 3 which is probably more moist than the average for the Tall Grassveld (Table 5).

Rainfall at each site is being recorded.

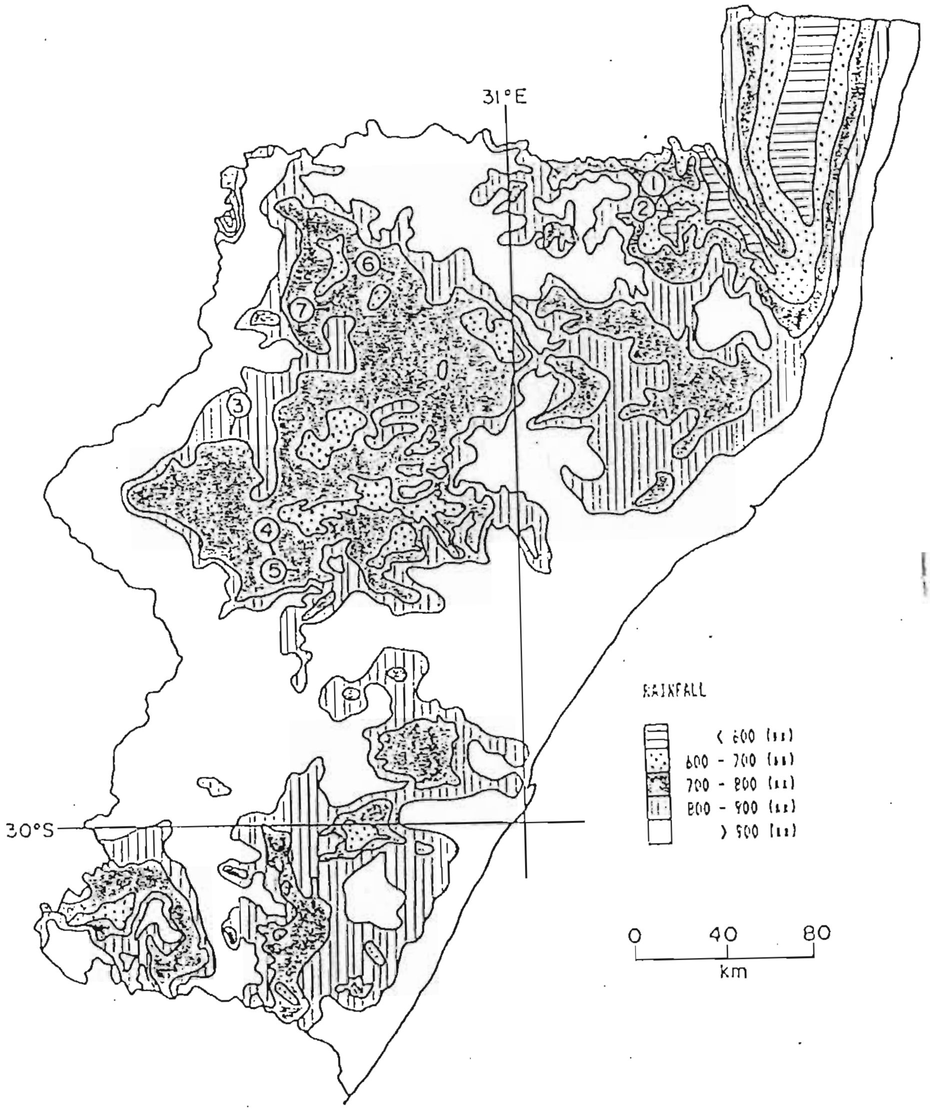


Fig. 5 of Appendix 1
Mean annual rainfall for Natal showing also the location of the sites (adapted from Schulze, 1982).

Table 5 of Appendix 1

Estimates of mean annual rainfall for each site. (LV, TG and SS are the Lowveld, Tall Grassveld and Sour Sandveld respectively.)

Veld Type	Site	Estimated mean annual Eainfall (mm)
LV	1 2	518 518
TG	3 4 5	830 725 720
SS	6 7	696 711

11 CONSTRAINTS OF COOPERATIVE TRIALS

The nature of the trials has had an effect on the design of these trials. Compromise has had to be reached between what is most desirable for research objectives and the limitations imposed by a co-operative basis for research. An additional consideration was the demonstration value of these trials for use in extension. There are both advantages and disadvantages to the co-operative approach. The aim was therefore to try and exploit fully the advantages and minimise the disadvantages of this approach.

a. There were several general advantages of these co-operative trials.

    1) There was no cost involved in purchasing land.

    2) Animals did not have to be purchased.

    3) The trials have an important extension function.

    4) To some extent farmer needs for research could be satisfied.

5) This approach allowed areas to be investigated which would otherwise not have been open for research.

b. There were several general disadvantages of these co-operative trials.

1) There was always a possibility that the trials at a particular site might be prematurely terminated.

2) It was not always possible to satisfy research objectives fully because availability of facilities depended entirely on the number of farmers who were willing to assist with the research.

3) The wide area over which the trials were located, as opposed to having a single location, made control more difficult. Therefore some compromises had to be made between management and design of the trials.

12 CONSIDERATIONS WITH RESPECT TO THE STOCKING RATES WHICH WERE APPLIED ON THESE TRIALS

A great deal of criticism has been levelled at the range of stocking rates applied on these trials. This therefore deserves special consideration.

As an extension tool these trials have, over the past three years, proved invaluable. This potential was realised from the outset. To have applied the range of stocking rates normally applied in stocking rate trials (where the heavy treatment is usually more than 100% heavier than the light treatment) would have resulted in a complete loss of credibility among the farmers whom these trials were established to assist. On the one hand, extremely light stocking rates would have resulted in derision. For example, many farmers in the Tall Grassveld viewed a stocking rate of 3,2 ha/LSU very sceptically as being of academic interest only. On the other hand, extremely heavy stocking rates which would have resulted in removal of animals from the trials at any time because of food shortages (which frequently occurs in stocking rate trials on experimental stations) would have resulted in equal loss of credibility. Farmers would argue that they do not have the ubiquitous "sky hooks" bestowed upon researchers for the removal and replacement of animals as a consequence of climatic vagaries. Incorporation of data from such treatments in analyses would have resulted in the complete rejection of any model that was developed. Had resources been available (both funds and manpower) and had there been the opportunity to apply 5 treatments at each site, then only could the luxury of such extremes have been considered.

It may also be argued (in retrospect) that the stocking rates were conservative. A thorough review of possible potential of these veld types was not possible because there were no data. Had data been available, the stocking rate treatments which were selected may well have been different and may well have covered a slightly heavier range. However, despite the apparently "good" performance of the heavy treatment versus the surrounding farmers in the first two relatively wet seasons, in the light of the dry spring experienced in the 1989, the dry season which was experienced in 1989/90 and the extremely dry spring currently being experienced in 1990, these stocking rates may well not be as conservative as the observations over the first two season suggested.

Differences for seasonal fluctuations cannot be compensated for in these trials. Farmers may well buy and sell animals opportunistically as the season progresses. In dry periods they may also supplementary feed with hay from fodder banks. This is not possible in these trials. The animals numbers will remain consistent irrespective of season and they will only obtain licks. This is realistic when one considers that the main objective is to determine the potential of the veld for animal production.

The previous allusion to 30% heavier and lighter than the recommended stocking rate is misleading in the range actually achieved. If the heavy stocking rates are calculated as a percentage of the light stocking rates then they are between 65% and 85% heavier.

While the models may be applicable over a fairly restricted range of stocking rates, they will certainly more than cover the range which is of interest to farmers. Thus while the models will perhaps cover a limited range of stocking rates from a purely academic view point, they will more than fulfil the practical role for which they have been developed.

13 THE USE OF A VELD CONDITION INDEX BASED ON KEY SPECIES FOR MODELLING

The use of a veld condition index (VCI) based on the key species method was adopted in the modelling for several reasons.

a. Turner (1988) tested the use of scores from 3 methods (the weighted quantitative climax method (WQCM), the productivity method (PM) and the key species method (KS) described by Heard, Tainton, Clayton and Hardy (1986)) of assessing veld condition in the development of herbage mass models in the Tall Grassveld. The VCI derived from the KS was superior to the scores of the other two methods in models for predicting herbage mass.

b. The veld in the Tall Grassveld has been relatively intensively studied compared with that in the Lowveld and the Natal Sour Sandveld. Key species weightings had only been developed for the Tall Grassveld. These weightings were described by the Heard et. al (1986) as tentative. There were no benchmark data for the Natal Sour Sandveld. There were also no reliable rankings of grasses for the PM in either the Lowveld or the Sour Sandveld. Thus 1) the rankings were discarded for the Tall Grassveld and 2) key species, although subjectively identified, could be chosen with reasonable confidence.

c. If possible, the parameter for measuring veld condition had to be simple for use by farmers.

It is in no way suggested or implied that this is the most suitable method that for assessing veld condition or for veld monitoring. All that was intended was to find a parameter which could be fairly easily measured and which could be used in predictive equations for herbage mass.

The key species chosen are generally associated with veld in good condition (verified by the similar ranking of all sites in the Tall Grassveld irrespective of the method used

(Turner, 1988)). The VCI used in this study is therefore a close reflection of veld condition. Referral to veld as being in "good" or "poor" condition based on the VCI is therefore quite reasonable.

14 PRESENTATION OF ANIMAL PERFORMANCE DATA

The animal performance data are presented graphically. The quadratic and cubic polynomial functions were fitted specifically to smooth the data, the purposes of which were 1) to calculate stocking rate and 2) to determine more accurately the seasonal turning points in animal performance. Tabulating the 107 quadratic and cubic functions developed for smoothing the animal mass gains would therefore serve little purpose in this dissertation.

Animal performance will be presented in terms of gain/animal. This has been deliberately done notwithstanding that animal performance data are usually presented in terms of gain/ha. Gain/ha is more appropriate to pastures. For veld gain per animal is probably more crucial. Gammon (1983) suggested that for veld the economic optimum is probably close to the point where maximum gain/head occurs. Turner (1988) also made the same suggestion although it was based on the level of veld utilisation. The importance of distinguishing between the presentation of result and the analysis of data from stocking rate trials on pastures and veld cannot be sufficiently stressed (see Chapter 3).

Gain per animal can easily be converted to gain per ha simply by multiplying the value by stocking rate (expressed in terms of animals per ha) or by dividing it by stocking rate (expressed in terms of ha per animal). Since this is a simple mathematical conversion, the presentation of the data in both forms seems unnecessary.

15 STATISTICAL ANALYSIS

Replication on the large scale that these trials are being undertaken would have been impossible without recourse to considerable funds and resources. Bransby (1982) suggested that replication in stocking rate trials could be substituted with treatments. Instead of being amenable to rigid statistical tests such as, for example, analysis of variance, the data from such unreplicated trials may be analyzed using various regression analysis methods (for example, Riewe, 1961; Jones and Sandland, 1974; Bransby, 1982; and Karnezos, Tainton and Bransby, 1988).

Confounding is always a major problem in the analysis of data in such trials. There are many factors which affect carrying capacity (Turner, 1988b) and therefore also stocking rate. It is, however, not possible to measure all parameters. Some confounding has therefore to be accepted.

Two approaches for analyzing the data were possible. The data from each site could have been analyzed in detail or the data from each veld type could have been analyzed in less detail. With the former approach, possibly the better approach from an academic viewpoint, three such dissertations would have been possible, one for each veld type. The objective was, however, to develop practical stocking rate models for each of the three veld types under study. This dictated that the latter approach be taken. Thus detailed discussion and analysis of data from each site, though it would have been interesting, was beyond the scope of this dissertation.

Bransby (1982, 1984) clearly showed the limitations of using single parameter models. He incorporated rainfall into a model and in this way was able to predict long-term economic optimum stocking rate using more than one parameter. It is thus clear that for veld, which is a multi-species sward and where both species composition and herbage maturity affect quality and quantity (Turner, 1988), an approach in which several parameters can be incorporated would be desirable. Stepwise multiple linear regression modelling, which can incorporate several variables (suggested by Draper and Smith (1981) and used for example by Karnezos et. al. (1988) and Turner (1988)) was chosen for developing models.

In developing the models, all data from sites within veld types was pooled. Seasons were regarded as treatments. Only those parameters included in the models are described. The coefficients of the models selected were all significant at the 5% level ($P < 0,05$) (suggested by Draper and Smith (1986)).

ADDENDUM 1 TO APPENDIX 1

LAY OUT OF THE SITES

The layout of Sites 1 to 7. The camps allocated to a particular stocking rate treatment are indicated by L, M, and H for the light, moderate and the heavy stocking rate treatments respectively. Camps in each stocking rate treatment in similar phases of the rotation were allocated a similar suffix e.g. L1, M1 and H1 were all in similar phases of the rotation at a particular site. The area (ha) of each camp is indicated below its number.

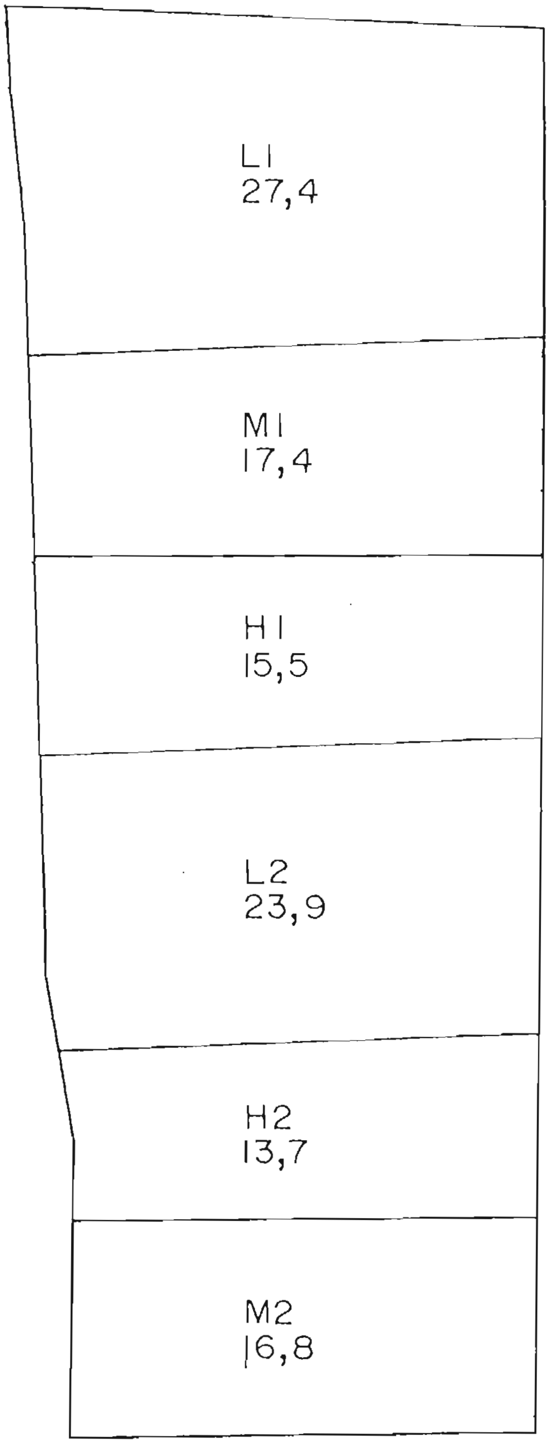


Fig. 1 of Addendum 1 to Appendix 1
The layout of Site 1.

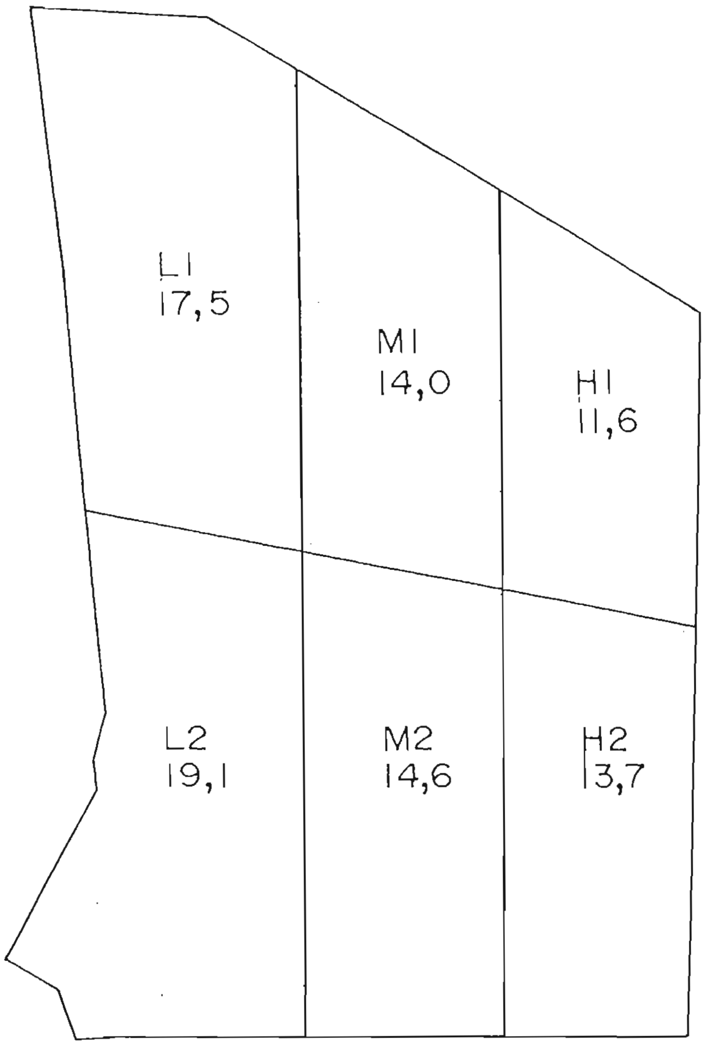


Fig. 2 of Addendum 1 to Appendix 1
The layout of Site 2.

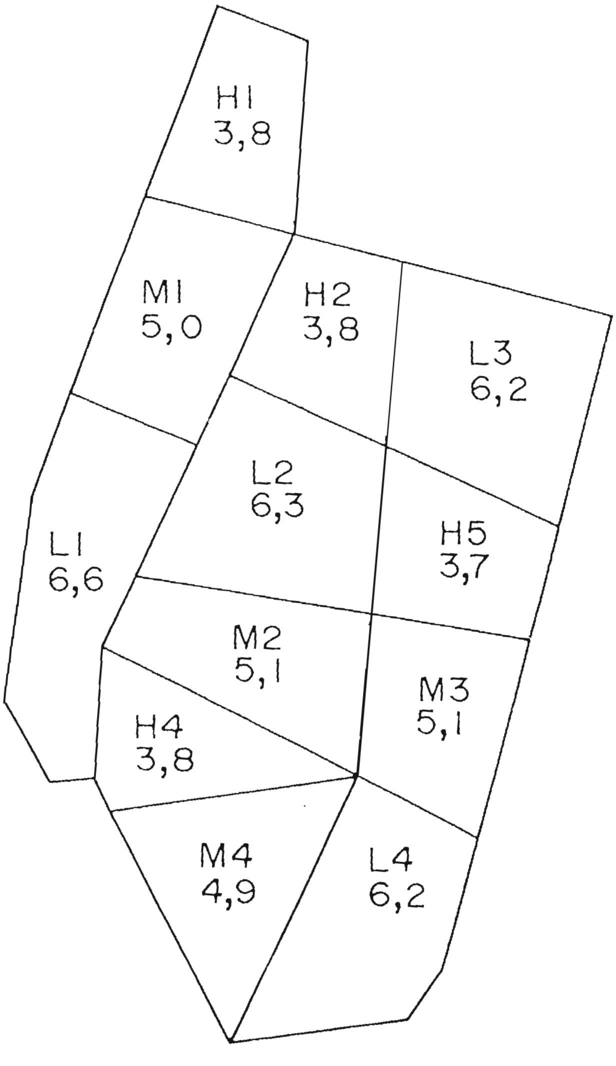


Fig. 3 of Addendum 1 to Appendix 1
The layout of Site 3.

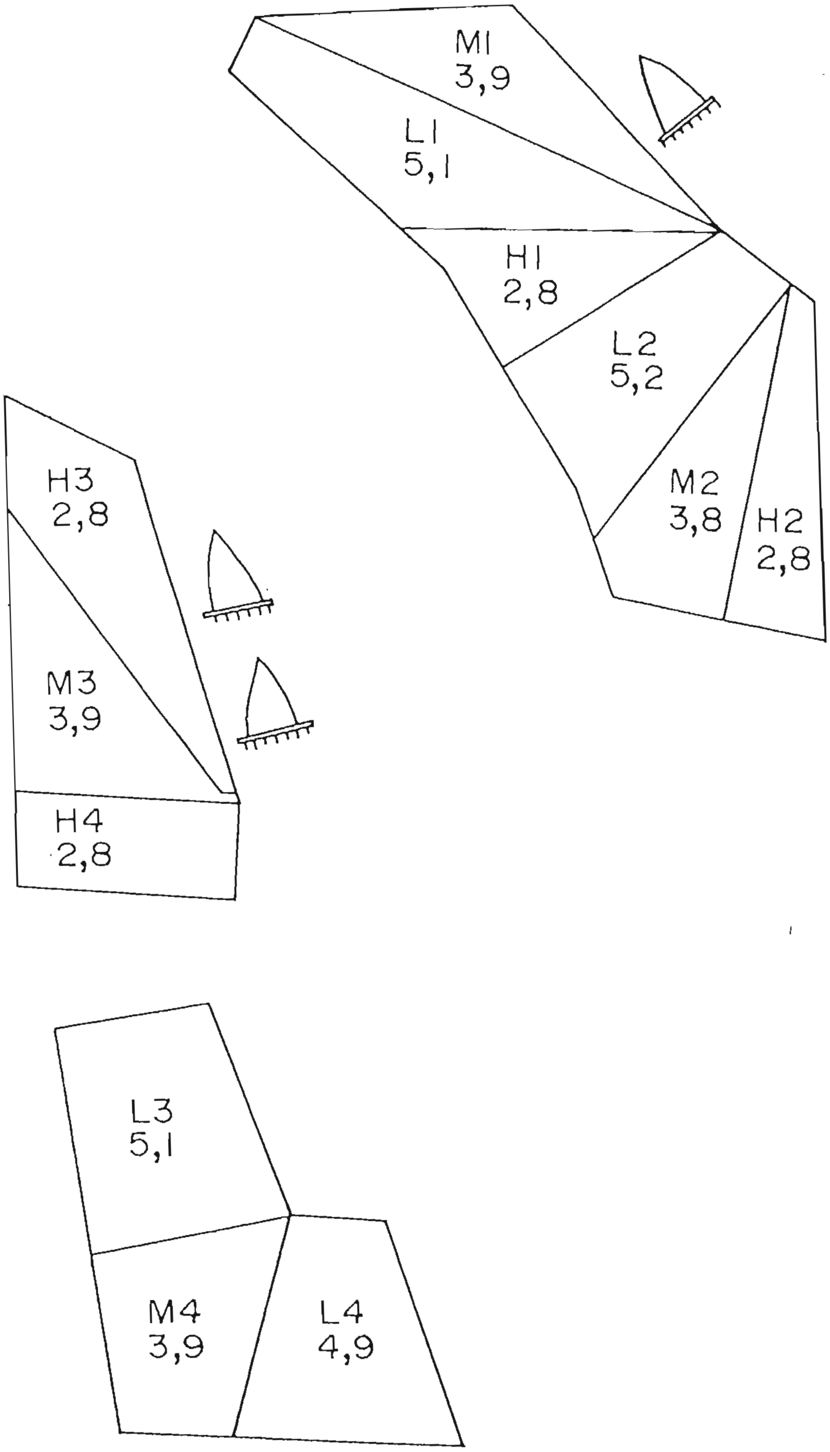


Fig. 4 of Addendum 1 to Appendix 1
The layout of Site 4.

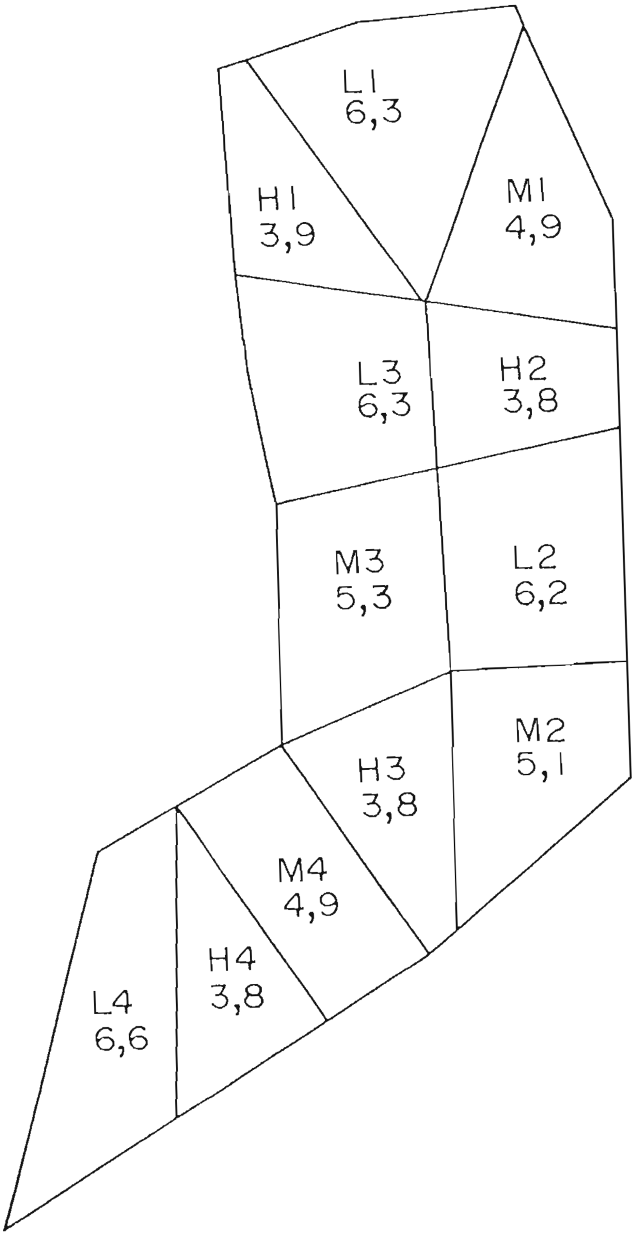


Fig. 5 of Addendum 1 to Appendix 1
The layout of Site 5.

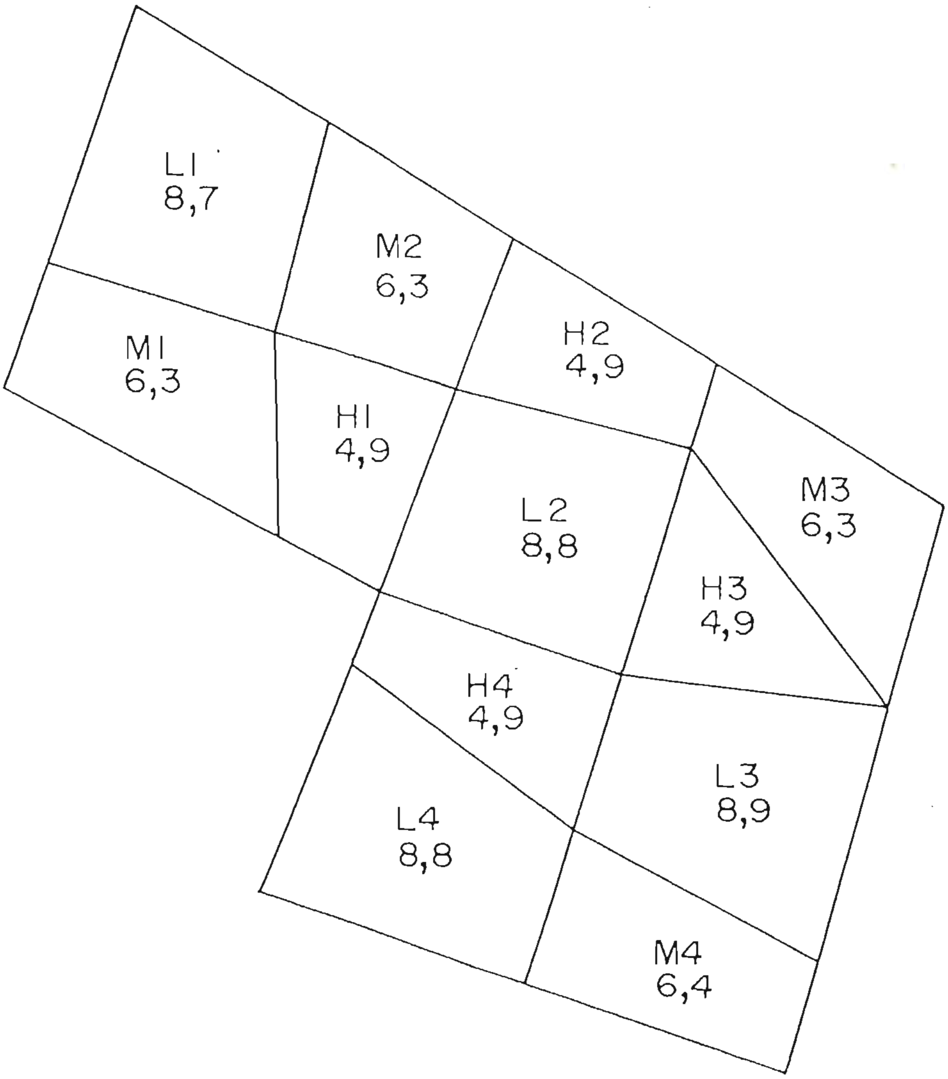


Fig. 6 of Addendum 1 to Appendix 1
The layout of Site 6.

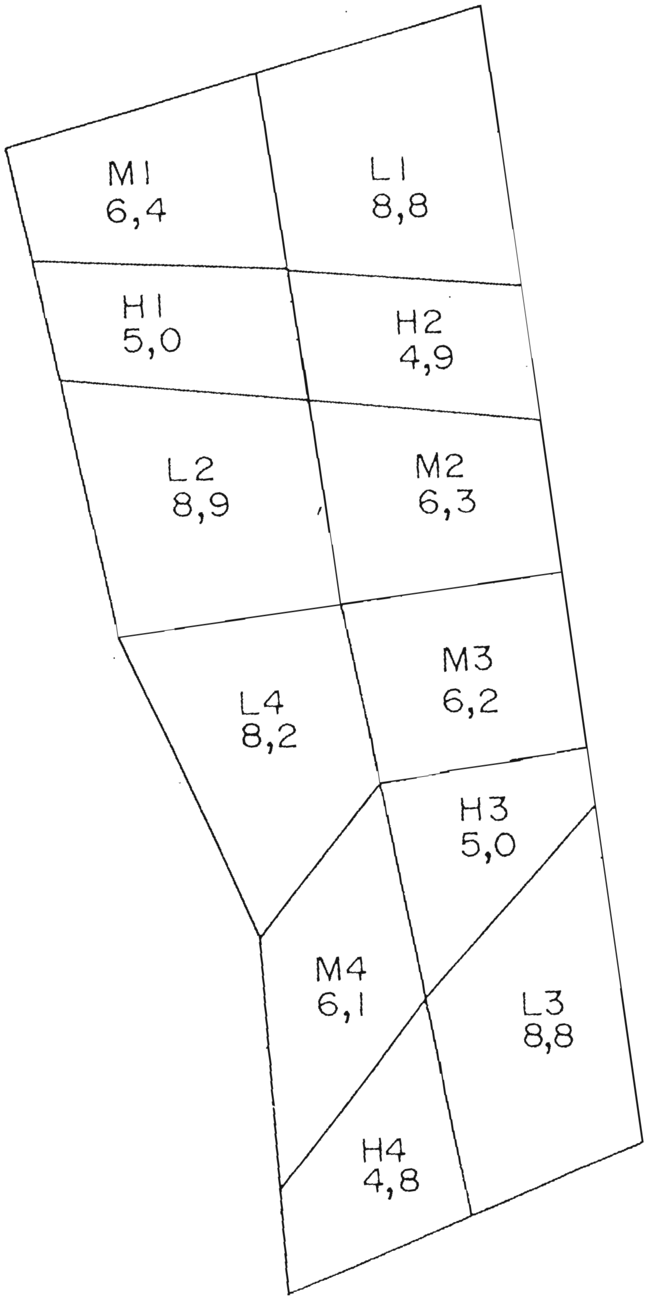


Fig. 7 of Addendum 1 to Appendix 1
The layout of Site 7.