The effects of long-term variation in rainfall and dry matter production of veld on the financial position of a beef weaner enterprise

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Four simulations (RANGEPACK Herd-Econ) of a beef weaner enterprise, each subjected for a period of 30 years to a different rhythm of the long-term variation in rainfall and simulated dry matter production (PUTU 11) of veld at Glen, were compared. These different rhythms were based on the historical sequence of good, average, poor and bad years over a period of 63 years. Management inputs for the beef weaner enterprise were identical for each comparable defined climatic year. The basic sets of biological variables for the cattle, namely, reproduction and growth rate of calves, heifers and cows, were identical for each simulation and differed only with respect to the specific defined sequence of climatic years that prevailed in each simulation. The same input costs and produce prices were applicable in all four simulations. Variation in climate, as determined by the specific rhythm of successive climatic years during each simulation, had a major influence on the financial results. The accumulated annual cash surpluses (in ascending order) of Simulations II, IV and III were (after 30 years), respectively, 6.8%, 12.8% and 14.1% higher than that of Simulation I. The consequences of poor and bad years, but also of the good years, which may have occurred at random during the lifetime of a livestock producer, are discussed.

Vier simulasies (RANGEPACK Herd-Econ) van 'n speenkalfproduksiestelsel, wat elk oor 'n periode van 30 jaar aan verskillende ritmes van die langtermyn variasie in reënval en gesimuleerde droë materiaalproduksie (PUTU 11) van veld op Glen onderwerp is, word vergelyk. Die verskillende ritmes in variasie berus op die historiese volgorde waarin goeie, gemiddelde, swak en baie swak jare oor 63 jaar voorgekom het. Bestuursinsette ten opsigte van die speenkalfproduksiestelsel vir elke simulasie was deurgaans identies vir die vergelykbare gedefinieerde klimaatstoestande. Die vier stelle basiese biologiese veranderlikes vir die beeste, naamlik reproduksie en groeitempo van kalwers, verse en koeie, was dieselfde in elke simulasie. Dit het slegs verskil na gelang van die spesifieke gedefinieerde fases van die klimaat wat in elke simulasie geheers het. Dieselfde insetkoste en produkpryse is deurgaans vir elk van die vier simulasies gehandhaaf. Variasie in klimaat, soos bepaal deur die spesifieke ritme waarvolgens die gedefinieerde jare tydens elke simulasie voorgekom het, het 'n groot invloed op die finansiële resultate uitgeoefen. Die geakkumuleerde jaarlikse kontant oorskotte (in stygende orde) van Simulasies II, IV en III was (na 30 jaar), onderskeidelik, 6.8%, 12.8% en 14.1% hoër as dié van Simulasie I. Die gevolge van veral die swak en baie swak jare, maar ook die goeie jare, wat lottoevallig tydens 'n vleisbeesboer se leeftyd mag voorkom, word bespreek.

Keywords: Cattle, climate, drought, modelling, PUTU 11, RANGEPACK Herd-Econ, risk, simulation.

Introduction

Variation in dry matter (DM) yield of veld (native pastures), primarily due to variation in rainfall, occurs in different years at any site in South Africa and is reflected in animal performance. In addition, negative effects of continuous overstocking and overgrazing on the DM production potential and stability of veld and, inevitably, also on animal production, must be considered. However, recently De Waal (1990) concluded: 'By applying sound pasture and animal management practices, the production levels attained by herds on veld in the Free State Region, are within reach of most livestock producers.' This may be an over-simplification of a very complex situation. In addition to the natural occurrence of drought, injudicious grazing practices and especially high stocking rates, which ultimately cause veld deterioration, increase the frequency and intensity of droughts and create so-called man-made droughts. According to Fouché *et al.* (1985), the incidence of 'feed droughts' at Glen is very low at a stocking rate of 6.2 ha/Large Stock Unit (LSU; Meissner *et al.*, 1983), while the probability of a 'feed drought' increases markedly to about 70% at a stocking rate of 3 ha/LSU.

This posed an interesting question. If variation in rainfall has such a marked effect on DM yield of veld and hence, on animal performance, what effect has the natural occurrence or sequence of years with average, below-average and higher-than-average rainfall on the financial position of a livestock production enterprise?

The aim of this study, therefore, was to investigate and, if possible, quantify the effect which chance, namely, the sequence in which a random number of consecutive years taken from the historical long-term occurrence of rainfall at Glen, would have on the financial position of a beef weaner enterprise. To accomplish this, two micro-computer-based simulation models were used, namely, PUTU 11 (Fouché, 1992) and RANGEPACK Herd-Econ (Stafford Smith & Foran, 1988; 1990; Foran & Stafford Smith, 1991). In this study, output from PUTU 11 (simulated annual DM yield of veld) partially served as input for RANGEPACK Herd-Econ. RANGEPACK Herd-Econ, a commercially available herd and property economic model, was designed specifically to track herds or flocks and associated cash flows through sequences of different climatic years, or years of different biological quality (Foran & Stafford Smith, 1991).

Procedure

In the more arid grazing zones of South Africa, many of the problems faced by livestock producers can be related to the effects of rainfall, both the inconsistency in distribution and variation in different years, and especially, the inability of producers to take adequate precautions to lessen the adverse effects on their production enterprises. An improvement of this situation re-quires, *inter alia*, a better understanding of the variation and variability of rainfall and the impact it has on DM production of veld and animal production.

Rainfall

Rainfall is the major driving force affecting DM production of veld and, therefore, animal performance. However, at present our understanding of this complex implied set of variables, as well as their interactions, can be questioned. Despite this statement, some progress has been made recently and there is a rudimentary knowledge and understanding of some of these factors.

The long-term annual rainfall of Glen Agricultural Development Institute (26°20′ E and 28°51′ S) for a period of 63 years (1929/30 to 1991/92), is presented in Figure 1.

In general, three aspects of rainfall must be emphasized. Firstly, the large and unpredictable variation in annual rainfall, and secondly, the incidence of years with below-average rainfall, which tends to exceed those with higher-than-average rainfall. Thirdly, another feature of rainfall which is often disregarded is the distribution of rainfall in a specific year. Some of this data for Glen, analysed over a shorter period of 47 years (H.J. Fouché, 1992; unpub. data), is shown in Table 1.

During this period of 47 years (1940 – 1987; Table 1), *c.* 80% of the annual rainfall at Glen was received between October and April, i.e. during the active growing season. Although the probability (P) of receiving consistent rainfall during this time is better than during the rest of the year, it still only varies between 51.4 and 61.1%. Furthermore, the coefficient of variation (CV) in veld production during the early part of the growing season (October – December), is markedly higher than later in the growing season. If all factors are considered, the results (Table 1) clearly show that the bulk of veld DM production at Glen really takes place during the period January to March, and especially during the latter two months.

Table 1 Rainfall and production variables for the respective months during a 47-year period (1940 – 1987) at Glen (H.J. Fouché, 1992; unpub. data)

	Rainfall		Veld production	
Month	mm[1]	% P^2	% CV^3	kg DM/ha[4]
July	9	20.2	0.12	–0.4
August	11	18.9	0.82	3.0
September	17	24.8	2.11	8.1
October	47	55.2	26.00	35.8
November	66	54.5	27.39	62.8
December	66	51.4	29.49	88.0
January	81	59.0	7.01	131.1
February	76	61.1	7.56	242.3
March	83	55.6	6.52	262.4
April	52	52.2	5.33	69.4
May	20	36.7	5.29	–131.7
June	9	26.4	5.27	–121.1

[1] Average monthly rainfall
[2] Probability of rainfall
[3] Coefficient of variation
[4] Growth rate per month

Dry matter production of veld

The livestock producer's main interest in rainfall lies in the resultant DM production of veld, or simply, of food for their animals. However, little quantitative information is available in this regard, i.e. DM production of veld resulting from rainfall. Until recently, the only method available to determine DM yield of veld was the conventional and laborious way of cutting, drying and weighing large numbers of herbage samples. Recently, Fouché (1992) reported on the development of a deterministic micro-computer-based model (PUTU 11) which, based on climatological (rainfall, maximum/minimum temperature, evaporation, sunshine hours, soil water balance), plant physiological and soil variables, simulates DM production of veld on a daily basis. The annual yield (kg DM/ha) of veld at Glen for the 63-year period (1929/30 – 1991/92), as simulated with PUTU 11, is presented in Figure 2.

As was to be expected, considerable variation in annual DM yield of veld is evident. A comparison of the two graphic presentations in Figures 1 & 2, suggests that the relationship between

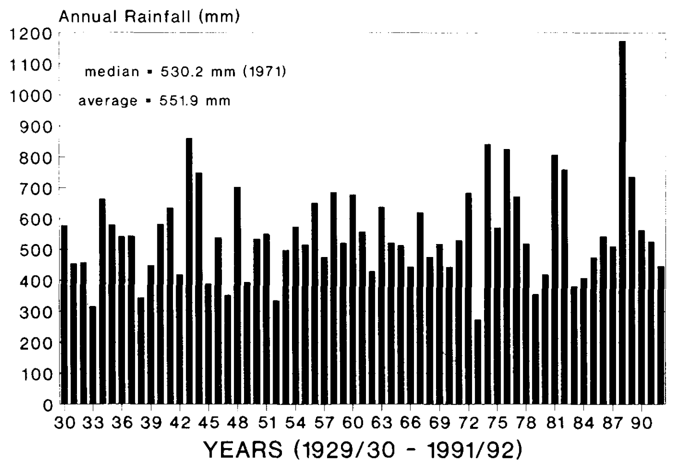

Figure 1 The long-term annual rainfall at Glen Agricultural Development Institute over a period of 63 years (1929/30 – 1991/92).

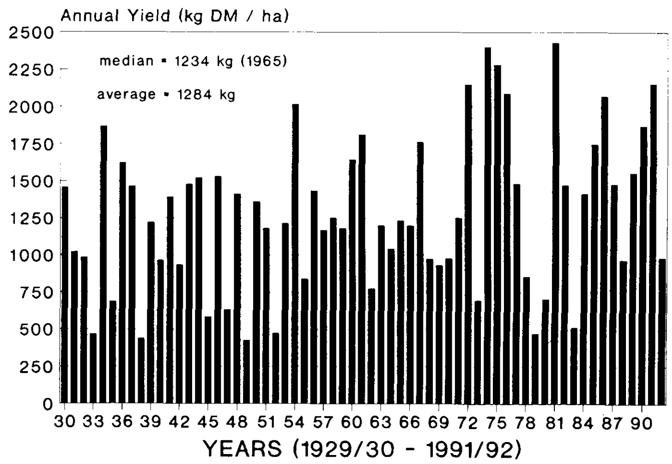

Figure 2 The annual yield (kg DM/ha) of veld at Glen Agricultural Development Institute for the period 1929/30 to 1991/92, as simulated with PUTU 11.

annual rainfall (mm/year) and DM yield of veld (kg DM/ha/year) is not very strong. The calculation of this relationship (r = 0.6) indicated that other factors, in addition to annual rainfall, play a role in determining DM yield of veld. Without negating the possible role of other factors in this regard, the distribution of rainfall within the growing season is probably one of the more important factors in determining DM yield of veld.

Defining **Yeartypes** for RANGEPACK Herd-Econ

It is not intended to describe RANGEPACK Herd-Econ fully in this article, but merely to demonstrate another application of this versatile utility (Stafford Smith & Foran, 1990). However, it is necessary to name two important features. Firstly, RANGEPACK Herd-Econ is designed to cope easily with biological responses to climate, i.e. mimic good and bad years, and secondly, it operates 'dynamically' rather than 'statically', i.e. follows the herd or flock through successive years to evaluate the lagged effects of climatic fluctuations on herd or flock numbers (Stafford Smith & Foran, 1988).

Four classes of climatic years, or **Yeartypes**, are available in RANGEPACK Herd-Econ, namely, **Good**, **Okay** (average), **Poor** and **Bad** (**terminology intrinsic to the command structure of RANGEPACK Herd-Econ is presented in bold throughout in this text**). A wide range of variables can be set for each **Yeartype**. Therefore, as a next step, and based on annual DM production or yield of the veld, the historical sequence of 63 individual years for Glen had to be classified or divided into these four classes or **Yeartypes**. A number of methods can be used to define the different **Yeartypes** for RANGEPACK Herd-Econ (Foran & Stafford Smith, 1991). However, scrutiny of the Glen data suggested the possibility of using natural break points in the ascending range of DM yields to create the necessary **Yeartype** classification. The simulated annual yields (kg DM/ha) of veld at Glen for the 63-year period, arranged in ascending order, are presented in Figure 3.

Based on this methodology and as shown in Figure 3, each of the 63 years was classified as being either a **Good**, **Okay**, **Poor** or **Bad Yeartype**. The main body of years was incorporated in the **Okay** (average) **Yeartype** group, with the remainder of the years at the higher end of the range into **Good Yeartypes**. At the lower end of the range, years were divided firstly into **Poor** and eventually into **Bad Yeartypes**. This yielded 13 **Good**, 26 **Okay**, 10 **Poor** and 14 **Bad Yeartypes**, with a distribution of 0.21, 0.41, 0.16 and 0.22, respectively, for the four **Yeartypes**. If the **Poor** and **Bad Yeartypes** are grouped together for comparison, the

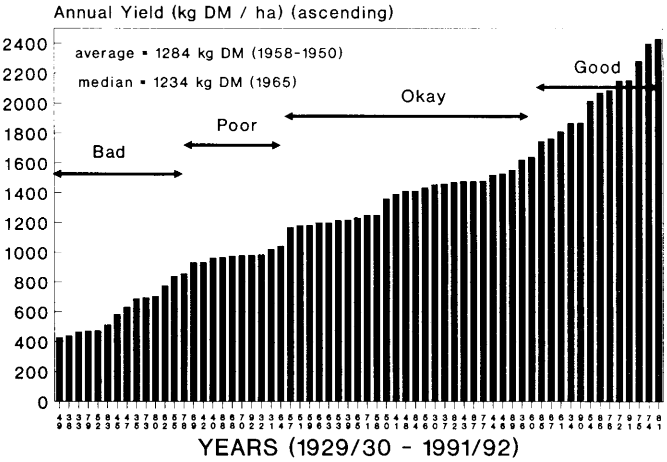

Figure 3 Simulated annual yields (kg DM/ha) of veld at Glen for the 63-year period (1929/30 – 1991/92), arranged in ascending order to define the four **Yeartypes** (**Good**, **Okay**, **Poor** and **Bad**).

distribution of 0.21, 0.41 and 0.38 for higher-than-average, average and below-average years (in terms of annual DM yield) at Glen, deviates from the approximate probabilities of 0.25, 0.50 and 0.25 for the situation in central Australia (Foran & Stafford Smith, 1991).

The next step was to decide on the sequence or basic rhythm in which the four different **Yeartypes** were to occur for the simulations by RANGEPACK Herd-Econ. The historical sequence in which the defined **Yeartypes** had occurred during 63 years at Glen was chosen. Although any sequence of simulation could have been performed (Foran & Stafford Smith, 1991), it was decided to use realistic sequences by drawing four simulations of 30-year periods from the historic record. A constant simulation period of 30 years was regarded as being a reasonable time-frame for the simulations, being among other things, the typical management lifetime of most producers. Although each of the four simulations commenced, and ended, 10 years later than the previous one, considerable overlaps remained in corresponding years between consecutive simulations. The specific sequence in which the different **Yeartypes** (**Good**, **Okay**, **Poor** and **Bad**) occurred during each of the four 30-year periods (Simulations I – IV), are given in Table 2.

The numbers and distribution of the four defined **Yeartypes** during the four 30-year sequences of simulation with RANGEPACK Herd-Econ, as shown in Table 2, are given in Table 3.

Table 2 The specific sequences in which the different **Yeartypes**' occurred during the four respective 30-year periods of simulation with RANGEPACK Herd-Econ

Simulation[2]	30-year Sequences of **Yeartypes**																													
I	O	P	P	B	G	B	O	O	B	O	P	O	P	O	O	B	O	B	O	B	O	O	B	O	G	B	O	O	O	O
II	P	O	P	O	O	B	O	B	O	B	O	O	B	O	G	B	O	O	O	O	O	G	B	O	P	P	O	G	P	P
III	O	O	B	O	G	B	O	O	O	O	O	G	B	O	P	O	O	G	P	P	P	O	G	B	G	G	G	O	B	B
IV	O	G	B	O	P	O	O	G	P	P	P	O	G	B	G	G	G	O	B	B	B	G	O	B	O	G	G	O	P	O

[1] Terminology intrinsic to the command structure of RANGEPACK Herd-Econ
Yeartypes: **Good** G; **Okay** O; **Poor** P; **Bad** B

[2] Simulation: I = 1929/30 – 1958/59
II = 1939/40 – 1968/69
III = 1949/50 – 1978/79
IV = 1959/60 – 1988/89

Table 3 Numbers and distribution (in parentheses) of the four defined **Yeartypes**[1] during the four 30-year sequences of simulation with RANGEPACK Herd-Econ

	Simulations[2]			
	I	II	III	IV
Yeartypes				
Good	2 (0.07)	3 (0.10)	7 (0.23)	9 (0.30)
Okay	16 (0.53)	16 (0.53)	13 (0.43)	10 (0.33)
Poor	4 (0.13)	5 (0.17)	4 (0.13)	5 (0.17)
Bad	8 (0.27)	6 (0.20)	6 (0.20)	6 (0.20)

[1] Terminology intrinsic to the command structure of RANGEPACK Herd-Econ

[2] Simulation: I = 1929/30 – 1958/59
II = 1939/40 – 1968/69
III = 1949/50 – 1978/79
IV = 1959/60 – 1988/89

Although the distribution of some of the four **Yeartypes** differed between the four 30-year sequences of simulation (Table 3), the basic distribution of the **Good** and **Okay** groups of **Yeartypes**, as well as the **Poor** and **Bad** groups of **Yeartypes**, corresponded favourably between simulations. However, the individual 30-year periods differed markedly in some cases from the general pattern of distribution for the 63-year sequence for Glen given previously, notably for the **Good** and **Okay Yeartypes**.

Defining the beef weaner enterprise

Variables relating to animal performance, as well as input costs and produce prices, are defined independently in RANGEPACK Herd-Econ for each of the different **Yeartypes**. Some of the basic biological information pertaining to the beef weaner enterprise, as defined for an **Okay** (average) **Yeartype** in the simulations by RANGEPACK Herd-Econ, is presented in Table 4.

Herd production is driven by birth, death and growth rates (Foran & Stafford Smith, 1991). Based on available data, as well as practical experience from large beef cattle herds on several Departmental experimental farms (De Waal, 1990), the biological variables for an **Okay Yeartype** (Table 4) were modified according to the situations expected to prevail during the defined **Good, Poor** and **Bad Yeartypes**, respectively. Some of these key biological rates are given in Table 5.

Table 4 Basic information pertaining to the beef weaner enterprise, as defined for an **Okay** (average) **Yeartype**[1] in the four simulations with RANGEPACK Herd-Econ

Size of enterprise	1 543 ha
Carrying capacity	6 ha/LSU[2]
Total number of LSUs	257
Cows	152
Bulls	8
Heifers (15% annual replacement)	60
Reproduction rate	90%
Mating season	
Cows	15 Dec. – 28 Feb.
Heifers (2 years old)	15 Nov. – 28 Feb.
Weaning mass (205 days)	240 kg

[1] Terminology intrinsic to the command structure of RANGEPACK Herd-Econ

[2] LSU = Large Stock Unit; Meissner *et al.*, 1983

Table 5 Some of the key biological rates pertaining to the beef weaner enterprise, as defined for the different **Yeartypes**[1] in the simulations with RANGEPACK Herd-Econ

	Yeartype			
Biological rate	**Good**	**Okay**	**Poor**	**Bad**
Reproduction (%)	90	90	84	76
Growth (kg/year):				
Calves (0–1 years)	350	330	310	290
Heifers (1–2 years)	100	90	80	70
Heifers (2–3 years)	80	60	30	20
Cows (4–5 years)	50	30	10	5
Cows (8–9 years)	5	–10	–20	–30

[1] Terminology intrinsic to the command structure of RANGEPACK Herd-Econ

Lastly, monetary values (South African Rand/cent) were entered into RANGEPACK Herd-Econ as input (operating costs) and output (produce prices) variables for the defined beef weaner enterprise. Operating costs were usually set on a per head basis for the different classes of animals, independent of the **Yeartype**. Since the critical connection in RANGEPACK Herd-Econ is that between climatic year type, biological rates and prices, produce prices were set on a per kg basis for the different classes of animals in each of the four **Yeartypes**, based on the assumption that climatic years would affect the reproduction, growth and condition of the animals differently. While the description of the enterprise is realistic, the study was based on a number of assumptions, particularly the responses of herd biological rates to the different climatic years. Obviously, it was not intended to capitalize on the 'luck/adversity that short-term high/low prices' might bring to the enterprise (Foran & Stafford Smith, 1991).

Results and Discussion

RANGEPACK Herd-Econ provides several possibilities to present output, i.e. it provides for a wide range of output in biological or financial terms, both in tabular or graphical format (Foran & Stafford Smith, 1991; Stafford Smith & Foran, 1988; 1990). In this study, the output for the four simulations of the defined beef weaner enterprise (Table 4) is presented in Figure 4 as the accumulated annual Cash Surplus over 30-year periods.

The specific sequence in which the defined **Yeartypes** occurred during each of the four 30-year periods had a marked effect on the financial position of the beef weaner enterprise. It must be noted that these differences in accumulated annual Cash Surplus are not necessarily minimums or maximums, since only four simulations were performed.

The relatively large differences in financial output (accumulated annual Cash Surplus) produced by the four simulations, can partially be ascribed to the effect of the specific sequences in which the four **Yeartypes**, i.e. **Good**, **Okay**, **Poor** and **Bad**, occurred during each of the four 30-year periods (Table 2). The magnitude and impact of these differences become more pronounced when presented (Figure 5) relative to the values for Simulation I.

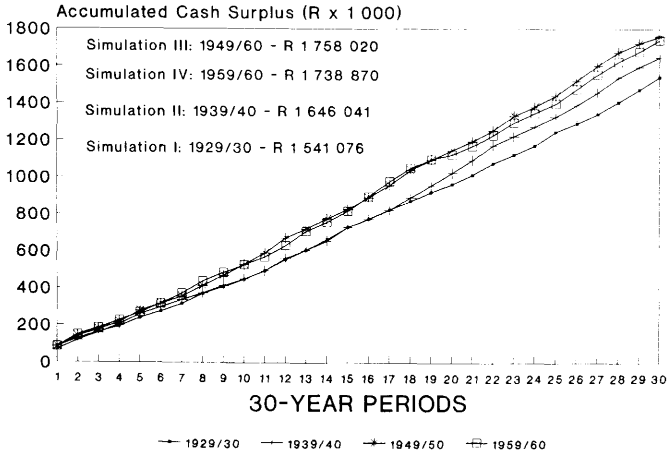

Figure 4 The accumulated annual Cash Surpluses for four simulations of the defined beef weaner enterprise over four different 30-year periods.

The four different **Yeartypes** had a strong impact on the accumulated annual Cash Surpluses and more specifically the sequence in which the **Good**, **Okay**, **Poor** and **Bad Yeartypes** occurred during each simulation. The distribution of **Yeartypes** (Table 3) does not reveal a clear pattern or trend to substantiate the observed differences (Figures 4 & 5). This suggests that the specific sequences of **Yeartypes** (Table 2), as well as small differences in the proportion of wet and dry years (Table 3), were instrumental in creating some, if not most, of the differences. There is a definite need to be more aware of both effects, especially in interpreting data which must inevitably pertain to some particular period. At the end of 30 years, Simulations II, IV and III, respectively, accrued (in ascending order) 6.8%, 12.8% and 14.1% more in annual Cash Surpluses than Simulation I (Figure 5). The maximum differences attained during the 30-year periods were, in the same order, respectively, 8.5%, 14.1% and 17.3%. These differences do not include any possible additional benefits derived from reinvestment of accrued annual Cash Surpluses. If this had been the case, the differences would have been much larger. However, the aim was simply to investigate and, if possible, quantify the direct effects of random sequences of years with

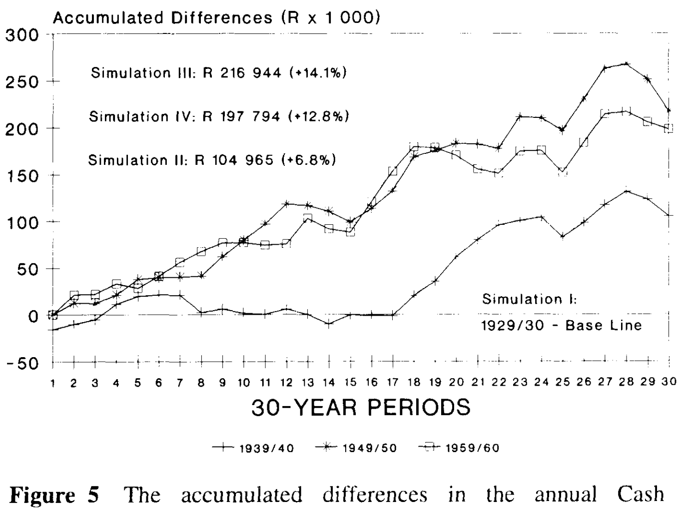

Figure 5 The accumulated differences in the annual Cash Surpluses for Simulations II (1939/40), III (1949/50) and IV (1959/60) during each 30-year period, in relation to Simulation I (1929/30 – base line).

average, below-average and higher-than-average rainfall. The relatively small size of the beef weaner enterprise and numbers of animals involved (Table 4), merely served as an example for RANGEPACK Herd-Econ to operate, and may be regarded as the bottom end of the situation in practice, since beef cattle enterprises are usually larger. The absolute differences (Rand values) in accumulated annual Cash Surpluses projected in this study by the four simulations (Figure 5) would have been more pronounced for larger beef weaner enterprises, but the relative differences (%) would have been similar. It should not be concluded from this study that because a beef weaner production system was used as an example in the simulations with RANGEPACK Herd-Econ, it in any way implies that this system is superior to a long-yearling, an ox or any other beef cattle production system.

The results show that, if a livestock producer had the opportunity to start his 30-year operation on four different occasions, i.e. either in 1929/30, 1939/40, 1949/50 or 1959/60, and applied exactly the same management skills and options during comparable climatic years for the next 30 years, then, purely by chance, he would have ended with vastly different financial returns. In order to minimize any further increases in differences relating to accrued financial returns, every possible long-term strategy and short-term tactic should be harnessed to the full advantage of the livestock producer. Appropriate utilization of a decision support tool like RANGEPACK Herd-Econ, and based on sound information and data, offers a cheap and quick method to evaluate the long- and short-term outcome of different strategies and tactics for livestock production (Stafford Smith & Foran, 1988; 1990; Foran & Stafford Smith, 1991).

The results of this study underscore the importance and impact of different climatic years on veld and livestock and, eventually, the financial returns of a livestock enterprise. As in Australia, it should be a major national priority to ensure that South Africa's livestock industries are sustainable. The implementation of some drought-related policies in Australia are considered to support unrealistic expectations of rainfall and subsequent production and, furthermore, government subsidies which aid the retention of animals during drought periods are seen as initiating the first steps of the degradation process of the natural resource (Foran & Stafford Smith, 1991). According to the 1989 Drought Policy Review Task Force (Commonwealth of Australia, 1989 as quoted by Foran & Stafford Smith, 1991), three policy strategies are to be pursued, namely, to encourage managers to be more self reliant in managing drought, to maintain and protect the environment and to facilitate post-drought recovery consistent with long-term sustainability. In a simulation study with RANGEPACK Herd-Econ, Foran & Stafford Smith (1991) explored the effects of drought on financial returns for three different grazing strategies for arid zone beef cattle properties in central Australia. They drew the following conclusions: Firstly, while higher stock numbers may give higher financial returns overall, those returns are more variable and risky. Secondly, a herd with high and resilient biological rates on an improving land resource can produce good returns with two-thirds the stock numbers of an alternative enterprise on a comparable resource base. Thirdly, the apparent advantages that the 'wait and see' manager has if the drought only lasts one year are quickly lost when the drought extends to the second and third years. These three conclusions, in the Australian context, apply similarly to the South African situation.

Although more simulations might have added to the detailed results of this study, the general conclusions would have been the same, namely:

1. The impact of variation in climate, especially variation and distribution of rainfall within the growing season, on DM yield is of paramount importance and must be realised and appreciated.
2. The impact of the above on livestock production, especially in biological and financial terms, must be understood and appreciated.
3. Management of veld and livestock production systems must be developed, improved and optimised with a view to minimise the potential adverse effects of risks, resulting from climatic variation, for livestock producers.
4. Micro-computer-based simulation models can, if applied judiciously, play an important role in developing long-term strategies and short-term tactics to manage the effects of climate on livestock production in South Africa.

In South Africa, concerted efforts should be aimed at a better understanding of drought and especially long-term drought management strategies and short-term tactics in livestock production. Needless to say, this can only be achieved if strategies are based on a sound knowledge and understanding of the factors involved. The ability to manage drought should become an integral part of livestock production, beginning with an awareness campaign for and the training of producers, advisers and policy makers. Drought should be seen and treated as part of the whole livestock production chain, differing only in intensity between years, and not as something which takes us by surprise every now and then. Drought should be accepted as a normal part of the farming system and not handled as a 'crisis' or regarded as an aberration.

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