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Overwintering of livestock has been regarded as a major problem in the region because of low rainfall, cold winters and uneven topography. The latter is predominantly sour veld; natural grazing becomes unpalatable in winter. The solution to the overwintering problem by moving animals to grazing outside the region is not feasible, so to determine optimal livestock and cropping systems. The best choice is to use arable land should supply the dairy herd with its roughage. The second best choice is to be used for cash crops (maize and dry beans), leaving no roughage. The third best choice is to keep dairy cattle, his second best choice - with much lower roughage requirements. The fourth best choice is to keep beef cattle, his third best choice - with much lower roughage requirements. The fifth best choice is to keep sheep, his fourth best choice - with much lower roughage requirements. The sixth best choice is to keep goats, his fifth best choice - with much lower roughage requirements. The seventh best choice is to keep pigs, his sixth best choice - with much lower roughage requirements. The eighth best choice is to keep chickens, his seventh best choice - with much lower roughage requirements. The ninth best choice is to keep ducks, his eighth best choice - with much lower roughage requirements. The tenth best choice is to keep turkeys, his ninth best choice - with much lower roughage requirements. The eleventh best choice is to keep geese, his tenth best choice - with much lower roughage requirements. The twelfth best choice is to keep guinea fow, his eleventh best choice - with much lower roughage requirements. The thirteenth best choice is to keep quail, his twelfth best choice - with much lower roughage requirements. The fourteenth best choice is to keep parrots, his thirteenth best choice - with much lower roughage requirements. The fifteenth best choice is to keep budgies, his fourteenth best choice - with much lower roughage requirements. The sixteenth best choice is to keep canaries, his fifteenth best choice - with much lower roughage requirements. The seventeenth best choice is to keep goldfish, his sixteenth best choice - with much lower roughage requirements. The eighteenth best choice is to keep koi, his seventeenth best choice - with much lower roughage requirements. The nineteenth best choice is to keep guppies, his eighteenth best choice - with much lower roughage requirements. The twentieth best choice is to keep betta fish, his nineteenth best choice - with much lower roughage requirements. The twenty-first best choice is to keep cichlids, his twentieth best choice - with much lower roughage requirements. The twenty-second best choice is to keep arowanas, his twenty-first best choice - with much lower roughage requirements. The twenty-third best choice is to keep piranhas, his twenty-second best choice - with much lower roughage requirements. The twenty-fourth best choice is to keep sharks, his twenty-third best choice - with much lower roughage requirements. The twenty-fifth best choice is to keep rays, his twenty-fourth best choice - with much lower roughage requirements. The twenty-sixth best choice is to keep eels, his twenty-fifth best choice - with much lower roughage requirements. The twenty-seventh best choice is to keep catfish, his twenty-sixth best choice - with much lower roughage requirements. The twenty-eighth best choice is to keep carp, his twenty-seventh best choice - with much lower roughage requirements. The twenty-ninth best choice is to keep goldfish, his twenty-eighth best choice - with much lower roughage requirements. The thirtieth best choice is to keep koi, his twenty-ninth best choice - with much lower roughage requirements. The thirty-first best choice is to keep guppies, his thirtieth best choice - with much lower roughage requirements. 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Die oorwintering van vee word beskou as 'n belangrike koue winters en ongelyke topografie. Laasgenoemde b natuurlike plantegroei is oorwegend suurveld; natuurlike vee-oorwinteringsprobleem gehanteer deur met hul vee Lineêre programmering is gebruik om optimale vee- en winsgewende boerderyvertakking is. Weiveld en bewerk hierdie behoeftes voldoen is moet die res van die bewerkte ruimte oor vir vleisbeeste of wolskape nie. As die boer winsgewend is - 'n kombinasie van kontantgewasse en wol en oesreste om aan hul voedingsvereistes te voldoen. Die weidings vir skape nie. Vleisbeeste is nie in staat om ekster in hierdie gebied is dus nie oorwintering nie, maar eerder

Overwintering of livestock has for long been regarded an important problem in high rainfall, sour veld areas. Much of the vegetation (predominantly grass) can provide lush food for livestock in summer, but loses palatability, digestibility and nutritional value in winter. Farmers have to find ways to provide alternative sources of winter feed.

In the Drakensberg regions many farmers have traditionally handled this problem by acquiring land in parts less affected by seasonal changes in the use value of natural grazing. They retained their farms in the high rainfall, sour veld regions as their main base of operations, and moved their livestock to winter grazing farms for approximately three to four months per year.

As agriculture became more commercialised and land higher, this practice became more expensive, and its importance waned. By 1985, approximately 27 per cent of farms in the Drakensberg grazing regions still trekked with livestock, mainly with sheep (Minnaar, 1990).

2. Area and farm system description

In the research, an attempt was made to determine an optimum organization for what may be regarded as a representative farm in the Northern Drakensberg grazing region, with Ermelo as the main centre.

In this region, mean annual rainfall varies between 600 and 1000mm, of which approximately 85 per cent occurs between October and March. The mean precipitation varies sharply over short distances (Weather Bureau, 1986; Afdeling Landbouproduksie-ekonomie, 1967). The precipitation has a high degree of reliability (approximately 80 per cent) (Transvaalstreek, 1985:5) and the region is also characterized by mist, cloudiness and high relative humidity (Transvaalstreek, 1985:7).

The region is regarded as temperate to cold, with a comparatively short growth period (Kotze, 1985). Frost occurs regularly in May, June, July and August (Transvaal Region, 1976), and snow often occurs during winter.

A variable topography and differences in soils limit arable areas (Transvaalstreek, 1983). The natural vegetation is sour grass, and acidification has occurred over the last 115 years. Grazing practices have contributed to deterioration of natural grazing (Acocks, 1975:5-7).

The present predominant farming system is a diversified one; livestock consists mainly of dairy cattle, woolled sheep and beef cattle. Arable land is used for feed crops and cash crops, particularly maize and dry beans. Approximately 27 per cent of farmers trek with livestock; there appears to be an inverse relationship between this practice and availability of crop residues (Minnaar, 1990).

3. Empirical model and data used

Linear programming was used to determine profit maximizing enterprise combinations, including intermediate production activities, for representative farms in the region. The model maximised sum of gross margins. It was a deterministic model and did not consider factors such as liquidity or solvency. Neither was risk included in the form of variability; the model was a pure static one.

Cropping activities included cash crops (maize and dry beans), maize silage, pastures (*Eragrostis*, kikuyu, rye, radishes and oats grazing) and hay (teff and *eragrostis*). Three types of livestock were considered: dairy and beef cattle and woolled sheep. Production of fodder (also from natural grazing) was determined on a monthly basis and expressed in terms of dry matter (DM) in kg per ha, metabolic energy (ME) in Mega Joules (MJ) per ha and digestible crude protein (DCP) in kg per ha. Estimates were made of quantities of unutilized nutritional value which could be transferred for use in subsequent months². The nutritional needs of livestock were expressed in the same terms.

The constraints in the model firstly consisted of constraints regarding available arable land and natural grazing. These constraints were based on median values obtained in a mail questionnaire survey carried out by Minnaar (1990).

Transfer activities formed an important part of the constraint matrix. Livestock numbers were constrained by feed requirements which could be met by natural grazing, feed crops, pastures, crop residues and feed purchases.

Some constraints were arbitrary: The dairy enterprise was limited to 115 cows lactating at any time (thus 393 animal units) and feedlots were not considered. Other arbitrary constraints will be noted when results are presented.

of the arable area (205,2 ha out of 276) was devoted to production of hay and to pastures, with the remaining 70,8 ha devoted to the production of maize and dry beans as cash crops.

Table 1: Summary of results obtained by linear programming

Model	A	B	C	D
Constraints:				
Dairy cattle (AU)	S*	≤ 393	= 0	=
Beef cattle (AU)	S	≥ 0	= 0	≥
Sheep (AU)	S**	≥ 0	= 0	≥
Arable land use (ha)	V	W	W	V
Purchase of licks (t)	≥ 0	≤ 10	-	≤
Land use:				
Sour veld (ha)	662,0	662,0	662,0	662,0
Mixed veld (ha)	326,5	326,5	326,5	326,5
Maize grain (ha)	151,3	56,6	220,8	211,3
Maize silage (ha)	-	-	-	-
Dry beans (ha)	31,7	14,2	55,2	53,2
Eragrostis past. (ha)	-	56,2	-	-
Eragrostis hay (ha)	36,0	19,3	-	36,0
Kikuyu pasture (ha)	-	-	-	-
Rye (ha)	-	-	-	-
Oats (green fodder) (ha)	-	91,7	-	-
Radishes (ha)	-	-	-	-
Teff (ha)	18,0	16,3	-	24,3
Crop sales:				
Maize (tons)	454,0	169,9	662,0	641,3
Dry beans (tons)	49,4	22,1	86,1	84,1
Eragrostis hay (ha equivalent)	13,6	-	-	-
Feed purchases:				
Teff hay (ha equiv.)	2,3	-	-	-
Dairy concentrate (t)	6,1	56,8	-	-
Winter licks (tons)	53,2	10,0	-	10,0
Total feed crop area (ha)				
	93,0	205,2	-	662,0
Livestock:				
Beef cattle (AU)	-	-	-	-
Dairy cattle (AU)	42,0	393,0	-	-
Sheep (AU)	21,9	-	-	18,0
Sum of Gross Margins	93265	279499	77989	78499

* S - Maximum number: those on farm during survey or feed availability

** V - Same proportion as during survey

*** W - Constrained by total area available

Crop residues were also utilized by the dairy herd, as well as natural grazing, leaving no room for either beef cattle or sheep. This system yielded a sum of gross margins of R279 499, which is a multiple of those obtained in other solutions.

Another important conclusion is the inability of beef cattle to compete with either dairying or woolled sheep. These results are particularly striking in the light thereof that in the model the calculated gross margins for beef cattle and sheep are higher than those for these enterprises *vis-a-vis* dairying if relative gross margins are compared with those obtained from members of the Agricultural Cooperative. A comparison is shown in Table 2.

In Solution B, the dairy herd would use up all the available feed (produced, purchased, crop residues and natural grazing). When one turns one's attention to solution A, the conclusion is

pays better to reduce sheep numbers to a level that can be almost completely sustained by natural grazing and crop residues.

5. Conclusion

The results obtained vindicate the opinion that the livestock problem in the high rainfall sour veld areas of the Drakensberg grazing regions is not primarily one of supplying sufficient winter feed for existing livestock. It is rather one of adjusting resource use and production systems to the natural and economic environment with the purpose of optimizing results.

The two most rational choices for farmers in this area, given the present economic environment, will be to concentrate either on dairying or on a combination of cash crops and woolled sheep.

Under present conditions dairying will by far be the most remunerative option. If this system is chosen, the arable land should mainly be used as pasture and for fodder production. After the requirements of the dairy herd have been met, the remainder of the arable land should be used for cash cropping (maize and dry beans). The dairy herd will, in this process, also use all available roughage from crop residues and natural grazing. The farm should supply all roughage; only licks and dairy concentrates should be purchased as feeds. The best use of the land resource appears to be supply a profitable dairy herd with its roughage needs and to use what remains for cash crops.

The second viable alternative appears to be the use of the arable land mainly for cash crops, and to keep sheep to utilize natural grazing and crop residues. A very limited amount of arable land should then be used to produce some hay and green fodder for sheep. Considerable plantings of pastures or feed crops for the purpose of sheep production do not appear to be viable. Neither does beef farming seem to be able to compete with either dairying, sheep or cash cropping for the use of land resources in these regions.

A third alternative which appears to yield almost as good results as the sheep - cash cropping alternative is to concentrate on cash cropping and rent out the unused grazing.

These results tend to indicate that land conversion which will change crop land over to fodder production and pastures will in these areas be viable only if the fodder and pastures are used for dairying. If, however, the whole region would get onto the bandwagon, the dairy market may become oversaturated.

The results also tend to support the notion that grazing in these parts have been heavily overstocked and mismanaged.

Notes

1. Based on an MSc (Agric) thesis by HA Minnaar at the University of Pretoria. The authors are indebted to Prof J van Zyl and Mr WF Lubbe for numerous suggestions. The research was funded by the Directorate of Agricultural Economics.
2. Sources for production of feedstuffs: Daines (1987), Kohlmeyer (1988), McDonald *et al* (1981), Van der Merwe (1977), Barnes (1988), Bekker (1987), Meissner (1986), Eden (1988), Esterhuizen (1988), Natal Region (1983a:82), Osterhoff *et al* (1979), Rethman (1988), Schoonraad (1985), Van Heerden (1986), Van Heerden (1988), Paulsmeier (1987).
3. Sources for nutritional needs by livestock: Meissner (1986), Natal Region (1983a:8), Natal Region (1985a:64-152), Natal Region (1985b), Natal Region (1983b:8).

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