STUDIES OF THE MANAGEMENT OF GRAZING RESOURCES ON THE MAKATINI FLATS AND PONGOLO RIVER FLOODPLAIN

By

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To Janet my wife, who has graciously accepted my preoccupation with my work on this thesis and lovingly helped and encouraged me during the three years I have worked on the Pongolo floodplain.

PREFACE

The experimental work described in this thesis was carried out in the Institute of Natural Resources, University of Natal, Pietermaritzburg, from January 1985 to June 1988, under the supervision of Professor Charles M. Breen.

The author hereby declares that the whole thesis, unless specifically indicated to the contrary, is his own original work and that it has not been submitted in any form to another University.

ACKNOWLEDGEMENTS

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SUMMARY

Subsequent to the impounding of the Pongolo river in the 1970's, development of irrigated agriculture on the Makatini flats has been reducing the area of vegetation available for grazing, and flooding patterns on the seasonally inundated Pongolo River Floodplain have been determined by the controlled release of water from the Pongolapoort dam. About 50 000 people live along the 10 000 ha floodplain within the 63 000 ha northern region of the flats which was studied. This population includes 2 970 registered cattle owners who own a total of 19 300 cattle.

The objectives of this study were: to gain an understanding of the Makatini pastoral system which would facilitate prediction of the effects of potential developments, including agricultural expansion, modification of floodplain hydrology and changed cattle management practices on the utility value of cattle; and to provide guidelines for the management of pastoral resources on the Makatini and other traditional African pastoral systems.

It was established that the value of cattle cannot be determined without understanding the importance of the subsistence utilities provided and that the value of utilities relative to each other influences the way in which the system is stocked and managed by the local people. The value of all marketed and non-marketed utilities was determined and the implications of the economic evaluation for the identification of management options in African pastoral systems assessed. Despite the "low productivity" of the Makatini system compared to western style ranches, cattle owners receive annual returns worth approximately 100 % of the asset value of their stock. This explains low market offtake rate in this and other subsistence systems. Non-marketed utilities, particularly milk production provide most of the returns to cattle owners.

The mean stocking density on the floodplain vegetation was estimated to be three times that of dry-land areas, but only 23 % of all grazing time is spent on the floodplain. Although floodplain forage provides an important supplement to winter grazing, its use is not vital to maintenance of animal condition. The coincident occurrence of an annual "stress period"; greater acceptability of *Echinochloa pyramidalis* vegetation as forage; the absence of floods; and the reduced use of floodplain fields, results in increased floodplain use in winter to a stocking density approximately ten times that of dry-land areas.

How the floodplain hydrology, rainfall and grazing interact with the crop growth rate and quality of *E. pyramidalis* stands was examined. The forage production potential of *E. pyramidalis* was found to be higher than that of other floodplain vegetation types and stocking densities of up to 4.5 AU/ha in summer and 2.5 AU/ha in winter are considered possible on the Pongolo floodplain. *Echinochloa* pastures may become wet and cause scouring if grazed exclusively, but grazing reduces plant moisture content and makes the forage more acceptable.

Local pastoral management was found to depend on the collective activities of cattle owners in pursuit of personal needs in a dynamic socio-economic context. Motivation for the manipulation of cattle numbers and herd composition is dictated by a cattle owner's perception of his needs for utilities and his ability to access those benefits. Because of this, the pastoral practices were found to be closely linked to other socio-economic activities such as agriculture and migrant labour. Stock owners have a narrow perspective of pastoral resource management and use strategies developed on small spatial and temporal scales.

In contrast development planners tend to identify objectives on a regional scale and on long-term (10 - 50 year) time scales and to orient management towards maximising the value of marketable utilities and preventing long-term overstocking. Management of pastoral resources in traditional African systems requires that the needs of local people be met, that the resource base be maintained; that pastoral policy be developed as a component of regional development planning and that close liaison between interest groups be maintained. Failure to establish or maintain this liaison is considered the main reason for the failure of many African pastoral development programmes.

It was recommended that local pasture management committees be established on the Makatini and that extension officers, trained specifically to understand management problems of Third World pastoral systems, be used to maintain liaison between stock owners and development planners. It was also suggested that formal cattle camps be established and managed by local people and that at least one flood (river flow > 200 cumecs) be released from the Pongolapoort dam each summer.

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION TO THE STUDY

In most traditional African pastoral systems stock are privately owned, but pastoral land is shared and thus the systems are generally considered to be communal (Cross *et al.*, 1982; Crotty, 1983; Krummel *et al.*, 1986; Hogg, 1987). These systems often appear to be overstocked and poorly managed (Bembridge, 1979; Blair-Rains & Kassam, 1980; Hundleby *et al.*, 1986) and in the past this has been attributed to the belief that cattle are kept as a sign of wealth or to improve the owner's prestige (Ayre-Smith, 1971; Webster & Wilson, 1980; Nankumba, 1982). Hardin (1968) attributed perpetual overstocking to the nature of quasi-communal systems in which the costs of pastoral resource degradation are shared by the community, but the benefits of stock ownership are received by individuals. His views are still considered valid (Tapson & Rose, 1984) although it is now recognised that a complex interplay between a wide range of social and economic factors, often specific to the system, usually exists. These interactions determine the rationale behind the way in which communal pastoral resources are used and it is generally accepted that pastoral management will be effective only if these interactions are well understood (Mwaniki, 1980; Colvin, 1983; 1984; Tapson & Rose, 1984; Krummel *et al.*, 1986; Starr, 1987; Boonzaier, 1987).

The low productivity of traditional African pastoral systems (Blair-Rains & Kassam, 1980; Loosli & McDowell, 1985) has resulted in numerous attempts to improve economic returns and efficiency in the use of grazing resources. Many of these livestock development programmes have been unsuccessful and their failure has been attributed to a lack of understanding of local traditions and the socio-economic structure of the systems (Horowitz, 1979; Baker, 1980; Santoir, 1983; Swift & Maliki, 1984; Halderman, 1985).

Wetlands are normally highly productive ecosystems (Etherington, 1983; Mitsch & Gosselink, 1986) and when water level fluctuations facilitate access by terrestrial herbivores, as occurs on floodplains, they usually provide good grazing (Attwell, 1970; Howard-Williams & Gaudet, 1985; Murillo *et al.*, 1986).

Drijver and Marchand (1986) estimate the floodplain area bordering large African rivers at 300 000 km ^{2} with many of these floodplains forming an important part of traditional pastoral systems (Dean, 1967; Campbell, 1976; Grandin, 1980; Scudder, 1980; De Groot & Marchand, 1982; Kloos, 1982; Marty, 1983; Salih, 1985). When planning the management of traditional African pastoral systems it is, therefore, essential that the role of floodplain and wetland pastures be considered.

Development planning on major African waterways has in most cases resulted in the construction of large dams that often cause major alteration of the floodplains down-stream (Attwell, 1970; Scudder, 1980; Breen & Heeg, in prep.). Drijver and Marchand (1986) reported hydrological modification caused by development on the Sudd, Niger delta, Bénoué, Tana, Senegal, Logone and Kafue systems and considered this, and the expansion of agriculture, to have reduced the area and accessibility of pastures in all cases. This shows that there is a need to establish how floodplain pastures are used by stock and to predict the effects of regional development on these systems.

Interactions between wetland hydrology, vegetation, livestock, stock farmers and other wetland users are complex and the investigation of these interactions requires an interdisciplinary approach (Grandin, 1980; Krummel *et al.*, 1986). Many studies of African pastoral systems on floodplains have been superficial (Gallais, 1967; Rzóska, 1974; Campbell, 1976; Denny, 1985) or have dealt with a specific component of the system in isolation (Furness, 1981; Morton & Obot, 1984; Slinger, 1988). Clearly a need exists for a strategy that can be used to plan the management and development of the traditional livestock industries that use African floodplain pastures; in particular, a planning strategy that can be used to predict the effects of hydrological modification and agricultural expansion. The onus is on resource ecologists to develop an understanding of pasture use that will enable predictions about system changes to be made and to formulate a holistic approach to stock and pasture management within a local socio-economic and development context.

A multidisciplinary ecosystem research programme in northern Natal, South Africa, provided an opportunity to study a traditional pastoral system in the context of developments associated with a large dam and its influence on the Pongolo river floodplain. The programme was initiated in the early 1970's in order to identify the determinants of floodplain ecosystem functioning and to develop a management programme which would maintain it as a renewable natural resource base (Musil, 1972; Furness, 1981; Heeg & Breen, 1982; Rogers, 1984). Initial emphasis was on ecological aspects but it was later realised that the authorities responsible for development would need information not only on ecological interactions, but also on interactions between people and the floodplain and that it was necessary to look ahead to the effects of future regional development (Heeg & Breen, 1982; Breen & Heeg, 1986). The large quantity of environmental and sociological research now published (Derman & Poultney, 1983; 1984; 1987; Heeg & Breen, 1982; Breen, in press) provides a good background on which to develop an understanding of the Makatini pastoral system and its environment. However, there has been no previous attempt to plan for stock management in this area or to incorporate pastoralism into regional development planning.

Endemic nagana and malaria, generally poor agricultural potential and inaccessibility all contributed towards preventing early development in Maputaland (Heeg & Breen, 1982). However, in 1972 the Pongolapoort dam was built to provide water for the irrigation of about 30 000 ha of alluvial soil on the Makatini flats surrounding the Pongolo floodplain. The floodplain ecosystem is a critical resource area for 50 000 local Thonga people and is dependent on floodwaters released from the dam. The Pongolo floodplain is situated in one of South Africa's least developed areas (Liddell, in press) and although migrant labour remittances are becoming increasingly important (Derman & Poultney, 1987), its inhabitants still maintain a largely traditional life-style (Buchan *et al.*, in press).

As in other regions in Africa (De Groot & Marchand, 1982; Marchot, 1983; Drijver & Marchand, 1986) pastoralism on the Makatini flats is threatened by both the potential modification of the floodplain's hydrological regime (Alexander & Roberts, in press) and the expansion of agriculture (Furness, in press). The Pongolo floodplain has plant communities with a floristic composition similar to that of many other African floodplains (Astle, 1965; Vesey-Fitzgerald, 1970; Rees, 1978a; Furness & Breen, 1980; Denny, 1985) and socio-economic pressures are not dissimilar to those in other rural African communities (Sperling, 1984; Njeru, 1984; Boonzaier, 1987; Derman & Poultney, 1987; Starr, 1987). It is hoped that this study of the structure and functioning of the Makatini pastoral system and the use and value of its pastoral resources, will prove useful for the development of a policy for local livestock management and will contribute to an improved understanding of managerial problems in African pastoral systems in general.

The objectives of this study were:

a) To develop an understanding of system structure and function that will facilitate prediction of the effects of potential developments, including agricultural expansion, modification of floodplain hydrology and changed cattle management practices, on the utility value of cattle;

b) To determine the utility value of cattle and pastoral resources; taking cognizance of factors such as the value of cattle sales, milk production, and draught power;

c) To identify spatial and temporal patterns of grazing resource use and their principal determinants;

d) To quantify the existing relationship between selected grazing resources (pasture types) and cattle;

e) To identify potential threats to the maintenance or increase in the utility value of the regional herd;

f) To develop guidelines for the management of livestock in the context of the flooding regime, agriculture and the local socio-economy;

g) To review the applicability of these observations in the context of African pastoral system management.

The thesis has three components: in CHAPTERS 2 to 5 the social and economic structure of the system is described; in CHAPTERS 6 and 7 the patterns of pasture use and the potential of vegetation to provide forage is discussed; and finally CHAPTER 8 deals with management planning for the Makatini and similar African pastoral systems.

1.2 THE STUDY AREA

Pastoral systems can be described as networks of interactions between the physical environment, vegetation, cattle and man (Tainton, 1981). The local physical environment and vegetation are described here to provide a framework for the discussion of interactions between components of the system, and to allow comparisons between the Makatini and other African systems to be made.

1.2.1 Locality

The study area includes 63 000 ha of the Makatini flats. All grazing land used by cattle which frequent a 7 500 ha area of the Pongolo floodplain between Ndumu Game Reserve and the Mjindi irrigation development, is included (Figures 1.1 and 1.2).

1.2.2 Geology and geomorphology

The soils on the Makatini flats determine where agricultural development is most likely to occur and thus which pasture areas may be lost. Soils are also important determinants of the type of vegetation present in the areas surrounding the floodplain, and of the susceptibility of land to erosion and pasture loss if the area should become overstocked.

The deposition of alluvium on the Maputaland plain, during a series of marine shoreline transgressions since the Miocene, has resulted in the development of a series of river terraces covering much of the Makatini flats and providing an isolated zone of soils with a high agricultural potential (Breen & Heeg, 1982; Figure 1.3). These areas are flanked in the west by soils derived from conglomerates eroded from the ryolytes of the Lebombo mountains, and in the east by recent sand deposits, which are old dunes associated with high water level shorelines during the sea level fluctuations (Figure 1.4).

Good agricultural lands are usually found on or near floodplains because of alluvial deposits and the Makatini is typical in this respect. Less common are the sandy soils which make some areas of the Makatini highly susceptible to wind erosion (Staples, C., pers. comm., 1987). As a result of these sandy soils the area is unusually sensitive to desertification through overstocking.

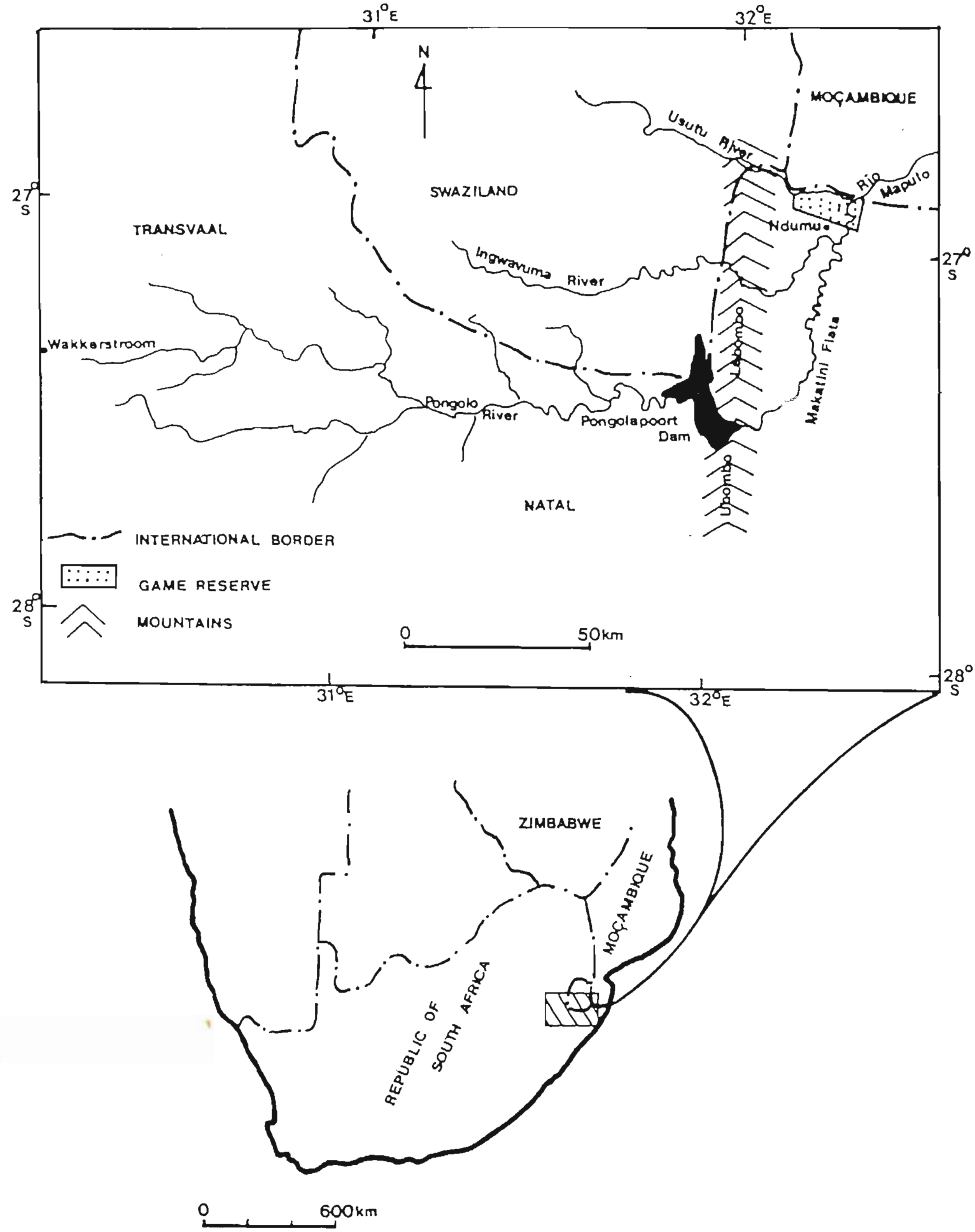

Figure 1.1 Location of the Pongolo river floodplain and its catchment (After Furness, 1981).

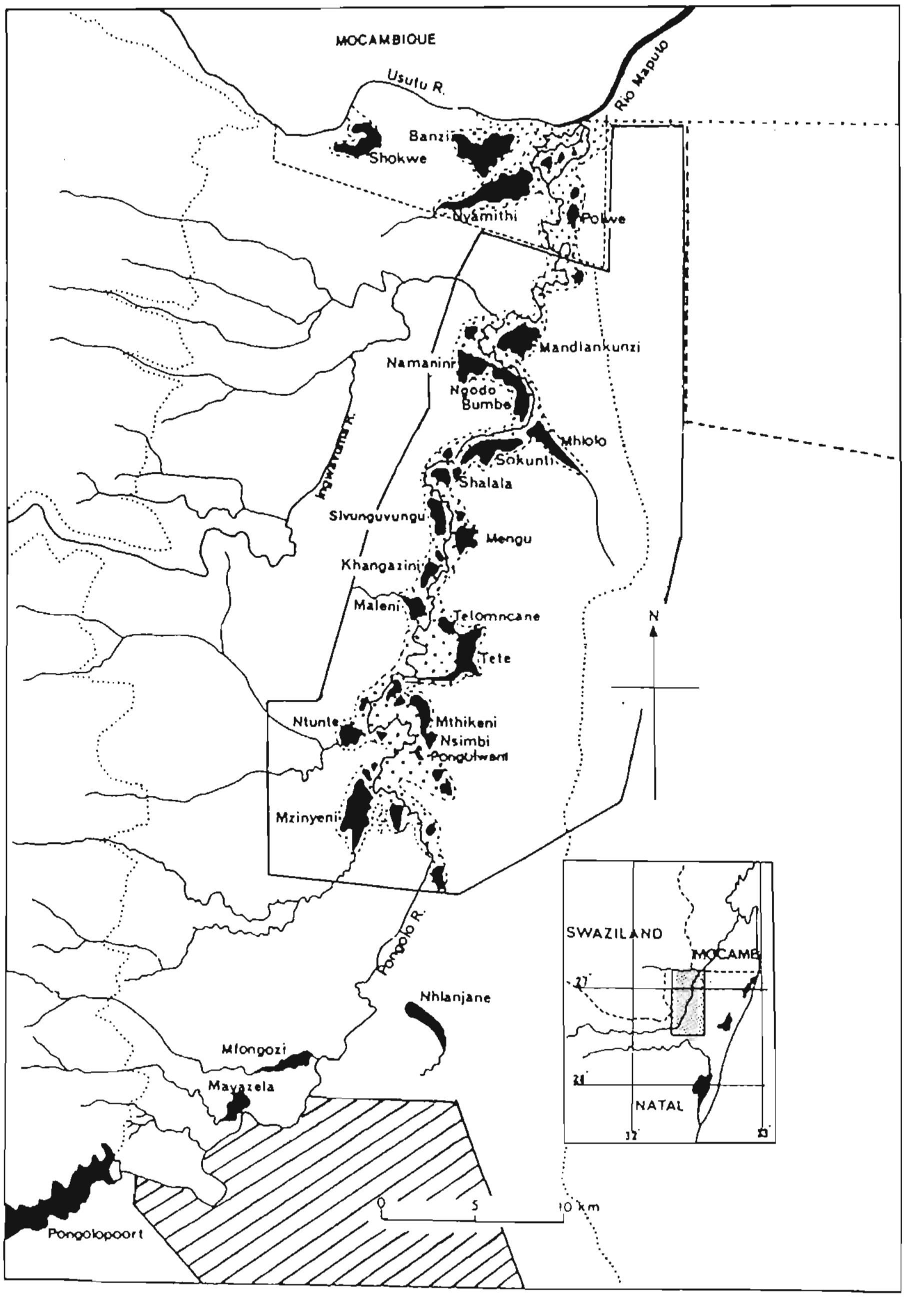

Figure 1.2 The study area, ——, showing the Makatini flats, ·····, the Pongolo river floodplain, ⬚, major water bodies, ■, the region of irrigated agricultural development, ▨, and Game Reserve boundaries, - - - (Adapted from Heeg & Breen, 1982).

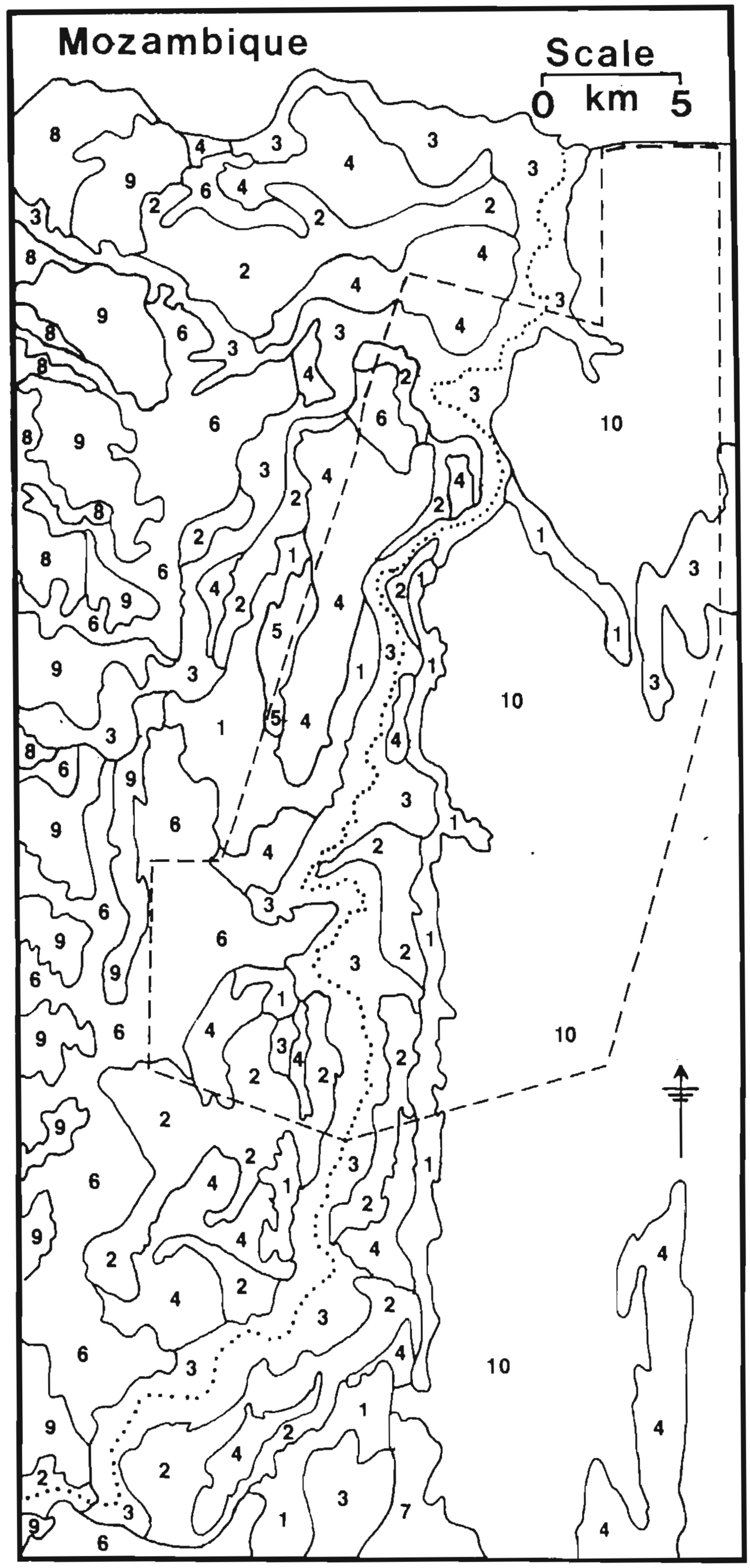

Figure 1.3 The soils of the Makatini flats (After Department of Agriculture, 1986). - - - - = Study area. ····· = Pongolo river. 1 = Red B horizon. 2 = Red B and other horizon. 3 = Red and yellow high base. 4 = Red high base. 5 = Yellow high base. 6 = Undifferentiated. 7 = Regic and other sands. 8 = Rock areas. 9 = Lime rare in uplands. 10 = Regic sands.

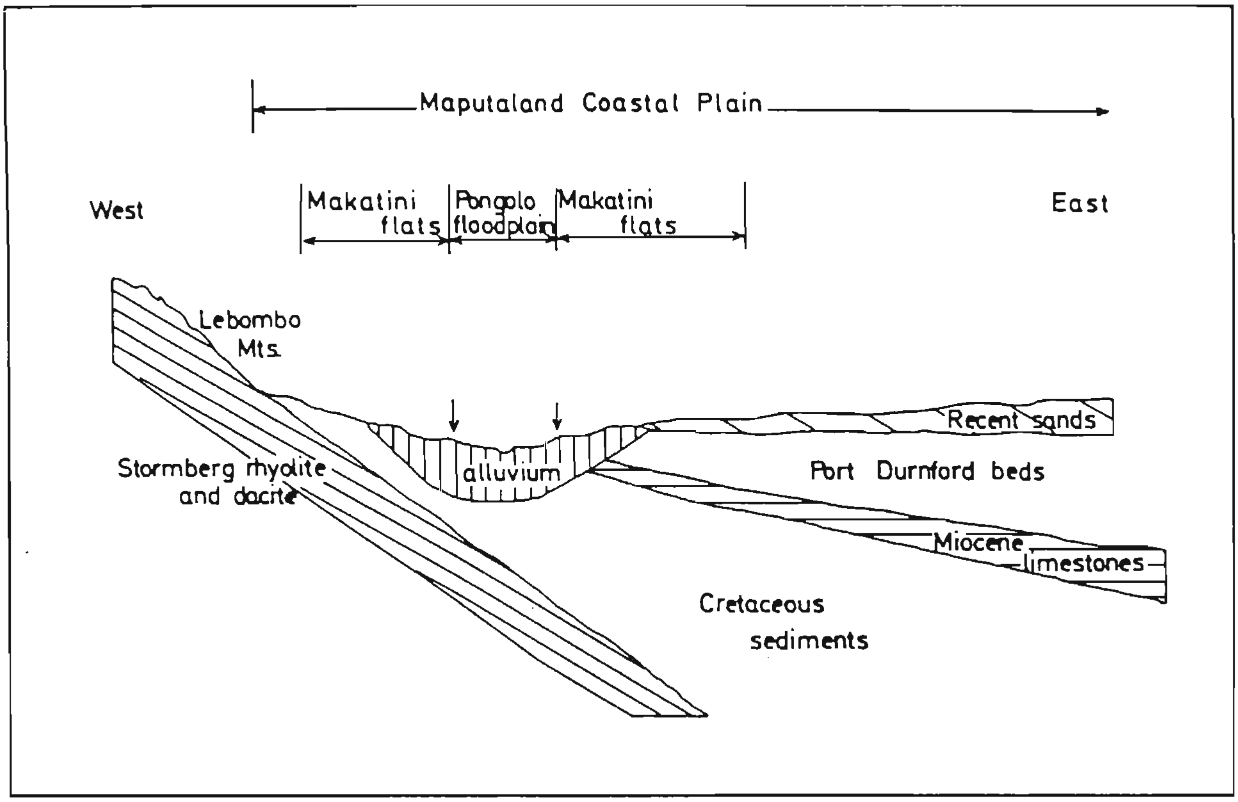

Figure 1.4 Geological section through western Maputaland (After Heeg & Breen, 1982).

1.2.3 Climate

Climatic conditions determine the fodder production potential of dry-land areas and when rainfall is low (below 625 mm/year) the range of pasture management options may be restricted (Visser, 1966). A total rainfall of 400 - 800 mm/year, falling mostly in a distinct wet season, occurs throughout much of Africa (Currie, 1983) which means that pasture use has to be geared to obtaining forage during annual "stress periods" when little or no forage production occurs. Climatic conditions also determine river hydrology and so the desiccation of the floodplain between floods has a direct bearing on the way in which floodplain pastures are used.

The climate in the study area is described by Schulze (1982) as being warm to hot, humid sub-tropical. Although the area receives some rain throughout the year, winters are drier than summers. The mean annual rainfall is only 610 mm (Data from Computer Centre for Water Research, University of Natal) and is highly variable (Figure 1.5A). Summer rains fall in storms, caused by cyclones which usually remain in the area for a few days, but which are interspersed with sunny periods lasting up to several weeks. Evaporation is high (2 388 mm/year class A) as a result of the high temperatures (mean monthly maximum 28.7 $^{\circ}$C) and high run of the wind (averaging 230 - 240 km/day between September and December), (Heeg & Breen, 1982; data from Makatini Research Station, 1966 - 1975).

Low mean annual rainfall, high variation about that mean and a marked seasonality in rainfall, as occurs on the Makatini, are characteristic climatic conditions throughout much of Southern, East and West Africa.

1.2.4 Floodplain hydrology and structure

The Pongolo River arises at an altitude of 2 200 m and during the first 300 km of its course through a 7 081 km ^{2} catchment area it descends rapidly to the Pongolapoort (80 m above sea level). Thereafter the slope drops to 1 in 3 000 on the Makatini flats (Heeg & Breen, 1982). In comparison with other African floodplains (e.g. Sudd, Niger, Kafue, Okavango delta and lower Zambesi), the catchment area west of the Lebombo mountains is small and close to the river's floodplain. Because of this, and the area's cyclonic summer rainfall

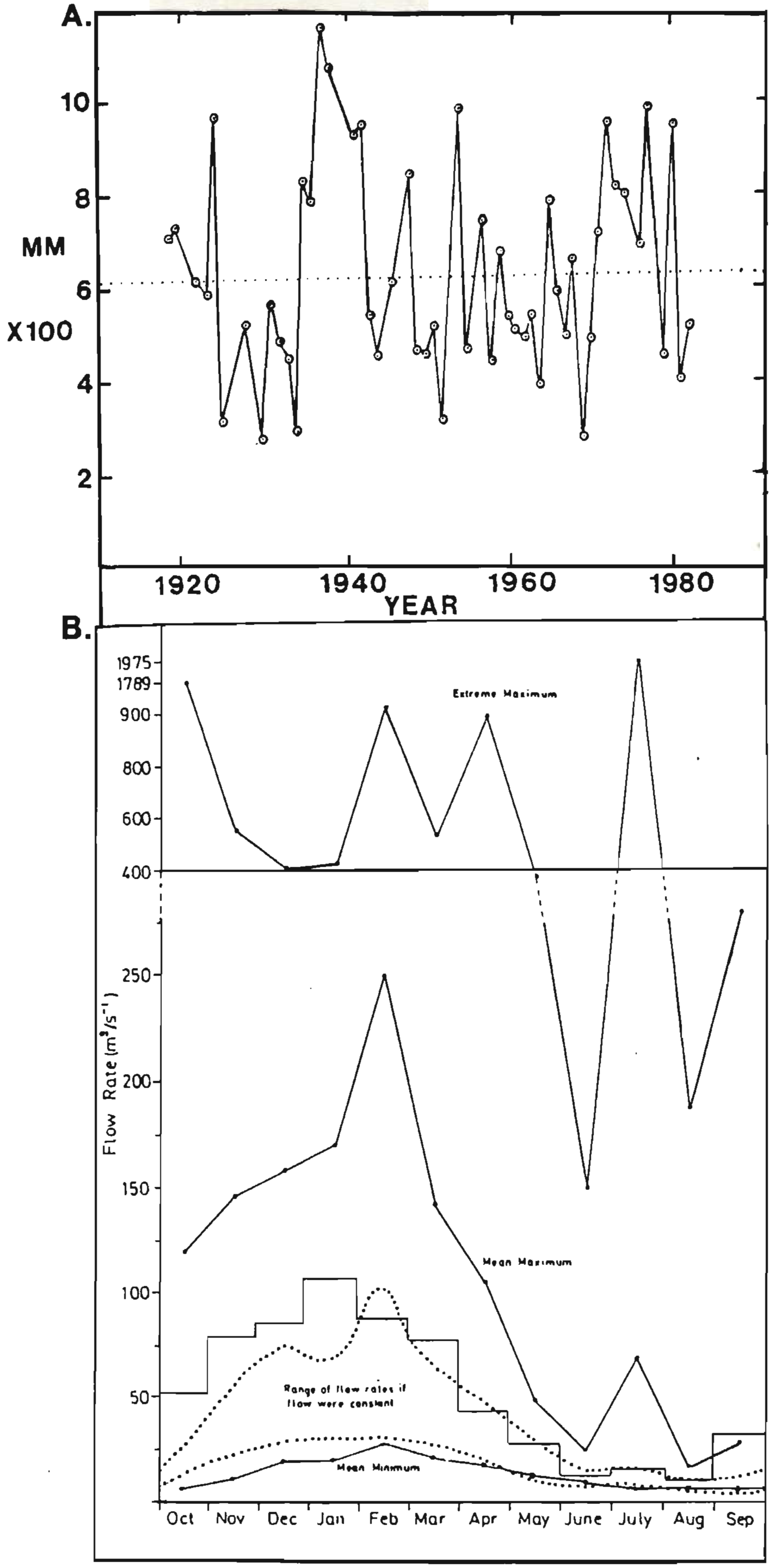

Figure 1.5 A. Annual rainfall at Ndumu, ---- and the long term trend (linear regression) in annual rainfall, ·····.
B. Mean and extreme maxima and mean minima in the flow rate of the Pongolo River (Data from Gollela gauging station 1929 - 1976). The range of flow rates if flow were constant, ..., is shown to illustrate the periodicity of floods. (After Heeg & Breen, 1982). The boxed line is mean monthly rainfall on the Makatini flats. (Data from Ndumu, 1919 - 1984, supplied by the Computer Centre for Water Research, University of Natal).

patterns, floods lasting several months and which have a single annual flood peak, like those characteristic of larger systems, do not occur. Instead, the river flow fluctuates rapidly and several floods of short duration (days or weeks) may occur each year (Figure 1.5B). Floods peaking at over 200 cumecs, and sufficiently large to inundate virtually all major pans, occur naturally two or three times a year, with nearly all floods taking place between October and April (Heeg & Breen, 1982). This flooding regime is important to pastoralism in that natural floods restrict access to floodplain pastures only for short periods during the season of high local rainfall and the area is most accessible at the end of winter (Figure 1.5B) when off-floodplain areas are at their driest.

The Pongolo floodplain comprises a low-lying area next to the river. It has numerous depressions which retain water for varying lengths of time after the recession of floods below the relatively high natural levees. The 80 recognised pans in the study area have a total area of 1 060 ha immediately after a flood, sufficient to inundate the full extent of the floodplain, has receded and they have lost contact with the river. Their area is only an estimated 460 ha after nine months without flood replenishment. The 6 500 ha area above maximum retention level of pans remains inundated only during flood events, but soils may remain wet for several months after a flood (Hensley & Furness, 1985).

1.2.5 Vegetation

The vegetation of the Makatini flats and Pongolo floodplain has been variously described (Acocks, 1953; Loxton & Hunting, 1969; Tinley, 1976; de Moor *et al.*, 1977; Moll, 1980; Furness, 1981). These studies differ with respect to the areas observed and the methodology used for vegetation zone identification. The regional distribution of vegetation types is shown in Figure 1.6 . Three main zones occur in the study area: floodplain vegetation, mixed bushveld including sparse woodland with interspersed sweetveld grazing, and deciduous sand forest.

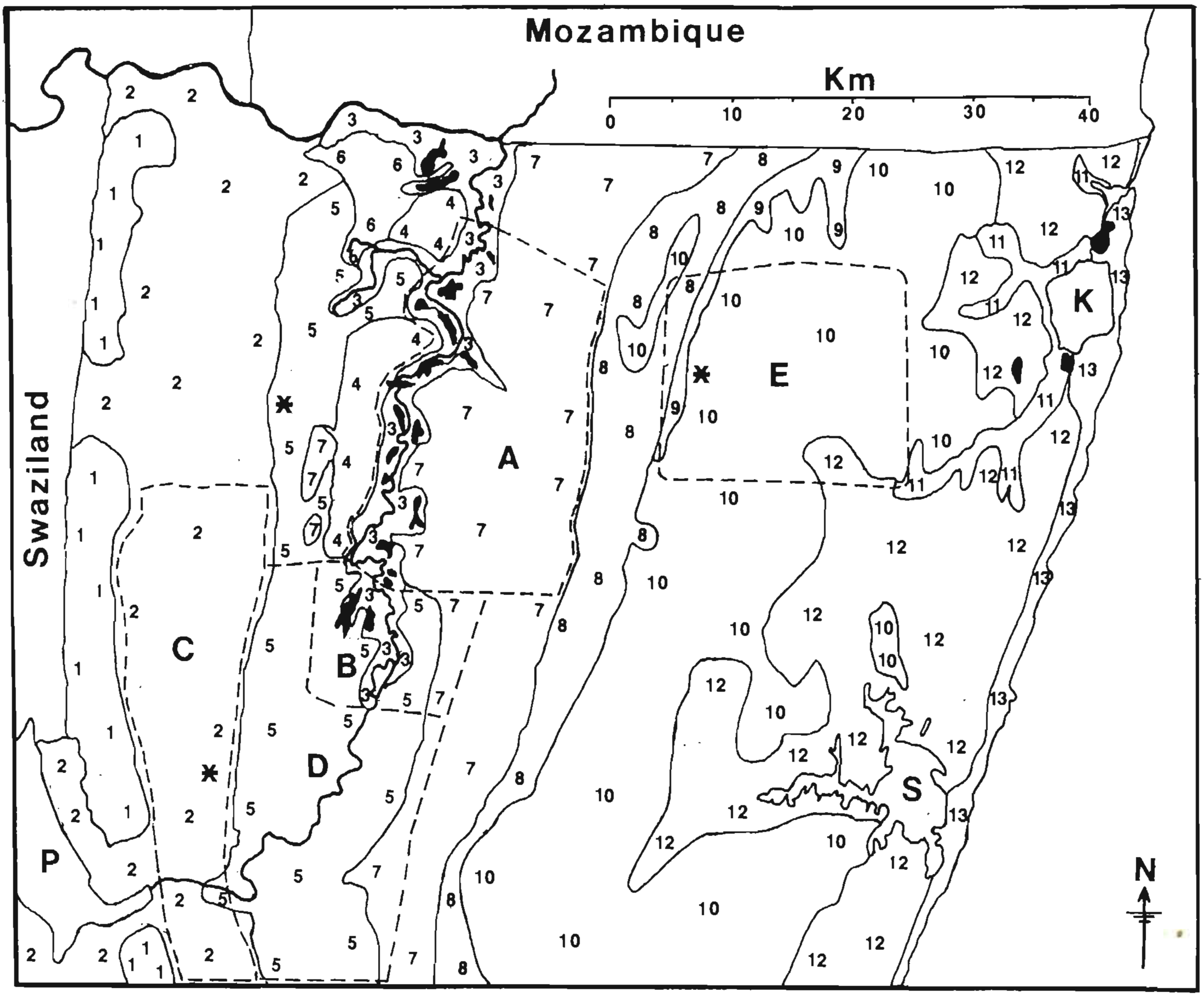

Figure 1.6 The vegetation of northern Maputaland. Modified from Moll (1980). 1 = Lebombo forest. 2 = Lebombo bushveld. 3 = Floodplain vegetation. 4 = Red-sand bushveld. 5 = Mixed bushveld. 6 = Thicket. 7 = Sand forest. 8 = Pallid-sand Bushveld. 9 = Mozi swamp. 10 = Palm veld. 11 = Swamp forest. 12 = Coast Grassveld. 13 = Dune forest. A - E are regions used to assess cattle condition in September 1986 (CHAPTER 6, Figure 6.2, p.78). * = Cattle sales yards. ■ = Water bodies. P = Pongolapoort dam. K = Kosi lake system. S = Lake Sibaya.

Five plant communities have been recognised in the seasonally flooded areas of the Pongolo floodplain (Furness & Breen, 1980; Furness, 1981):

a) The *Acacia xanthophloea* Benth. - *Dyschoriste depressa* community which occupies approximately 100 ha at the edge of the floodplain and is inundated only when the river is in full flood (river flow > 200 cumecs).

b) The *Ficus sycomorus* L. - *Rauvolfia caffra* Sond. community which occurs on the levees where the water table is always high and inundation occurs only when the river is in full flood. This community is now restricted (< 200 ha; Furness, in press) since much of the riparian vegetation has been cleared from the levees to make fields.

c) The *Cynodon dactylon* (L.) Pers. community which covers about 443 ha, forming extensive lawns around some pans. It experiences inundation whenever the pans are filled and is gradually exposed as the floods subside and pans dry out.

d) The *Cyperus fastigiatus* Rottb. - *Echinochloa pyramidalis* (Lam.) Hitch. and Chase community which covers a large area of 1 035 ha and occurs in the low-lying marshy areas which remain wet for most of the year.

e) The two *Phragmites* species; *P. australis* (Cav.) Trin. ex Steud. which occurs in flat swampy areas, and *P. mauritianus* Kunth. which occurs on river banks, pan margins and inlet-outlet channels where water level fluctuations are marked. These communities have a joint area of approximately 173 ha .

Furness (1981) mapped floodplain fields and areas disturbed by agriculture as a separate vegetation type. These areas are characterised by genera such as *Maytenus*, *Dichrostachys* and *Sesbania* and include a wide range of herbs and grass species. Disturbed areas cover approximately 2 675 ha of the floodplain in the study area.

The trees occurring in the mixed bushveld in the south and west of the study area are mostly *Acacia tortilis, Spirostachys africana, Schotia brachypetala, Lonchocarpus capassa* and *Euclea* species. The poorly developed grass understory consists mostly of tussocked genera such as *Eragrostis, Aristida, Bothriochloa* and *Sporobolus* (Moll, 1980). The mixed bushveld in the north-east of the study area consists mostly of *Acacia burkei, Sclerocarya caffra* and *Strychnos* spp. and the better developed grass understory contains species of *Panicum, Aristida, Hyperthelia, Pognarthria, Digitaria, Sporobolus* and *Heteropogon* (Pooley, 1978; Moll, 1980).

Newtonia hildebrandtii, Cleistanthus schleeteri, Hymenocardia ulmoides and *Balanites maughamii* are among the common trees in the sand forests which dominate the eastern regions of the study area. The forest is mostly dense and has a thick sub-canopy of shrubs and small tree species, but relatively few herbs (Tinley, 1976). There is, however, a more open matrix surrounding the patches of dense forest. This matrix consists of *Strychnos, Terminalia* and *Acacia* tree species and an almost continuous understory of tussocked grasses including *Aristida, Digitaria, Themeda, Urochloa* and many other genera.

Stock "carrying capacities" for floodplain, mixed bushveld and sand forest communities were estimated at 0.09, 0.14 and 0.07 AU (animal units)/ha respectively by Loxton and Hunting (1969). Tainton (1981) estimated carrying capacity for the vegetation of the Makatini flats as a whole at 0.07 - 0.17 AU/ha .

The dominant plant species present on the Pongolo floodplain are also common on many of the large African floodplains. *Phragmites mauritianus, P. australis, C. dactylon* and *E. pyramidalis* have been recorded as common on floodplains throughout Africa (Burnett, 1951; Vesey-Fitzgerald, 1955; 1963; 1970; Clayton, 1967; Dean, 1967; Cook, 1968; Fernandes et *al.*, 1971; Gordon-Gray & Ward, 1971; Howard-Williams & Walker, 1974; Rzóska, 1974). *Cyperus fastigiatus* has not been recorded in tropical areas but is closely allied to the more tropical *Cyperus auricomus* (Ross, 1972; Furness, 1981).

The pastures of the Makatini flats are not unusual in that the vegetation of the Pongolo floodplain is similar to that of other African floodplains and wooded savanna and deciduous forest on sandy soils are widespread African vegetation types (Eyre, 1968).

1.2.6 Conclusions

The physical environment and vegetation of the Makatini flats and Pongolo floodplain are similar to those found in pastoral systems incorporating floodplain pastures in areas of southern, East and West Africa. The Pongolo floodplain appears to differ only with respect to the nature of the flooding regime, having flood events which are less predictable and of shorter duration than on the larger floodplains because the river system is small. The similarity with other systems makes the Makatini a suitable area for a case study of the structure of African pastoral systems which use floodplain pastures. The difference in hydrological regime from large systems means that determination of the patterns of pasture use will be particularly important for the development of local management policies.

CHAPTER 2

THE SOCIO-ECONOMIC CONTEXT OF CATTLE OWNERSHIP ON THE MAKATINI FLATS

2.1 INTRODUCTION

The system's socio-economic context determines both the value of resources and the range of manipulations that cattle owner/managers are likely to make or find acceptable (Palmer & Parsons, 1977; Low *et al.*, 1980; Sandford, 1982). Socio-economic conditions in an area must, therefore, be understood before recommendations for improved pastoral system management can be made. Social and economic conditions in any population change continually and the motivations and attitudes of people are best understood if placed in an historical context (Beukes, 1987; Derman & Poultney, 1987).

The lack of success in African pastoral development programmes has, in many cases, been attributed to the failure of planners to understand the socio-economic conditions under which cattle owners make management decisions or to understand the history and traditions of pastoral practices (Horowitz, 1979; Baker, 1980; Santoir, 1983; Swift & Maliki, 1984; Halderman, 1985).

In this Chapter the present social context of pastoralism on the Makatini and the history of animal husbandry in the region are described. The importance of these factors in planning the development of the pastoral system is then discussed.

2.2 THE SOCIO-ECONOMY OF THE MAKATINI FLATS

Inhabitants of the study area live essentially within a subsistence agricultural economy, although most families do have a small cash income (Krige, 1982; Poultney, 1982; Derman & Poultney, 1983; 1987). Maize is the main subsistence crop and is grown, along with a wide range of vegetables, on both seasonally inundated and dry-land areas (Buchan *et al.*, in press). Most families locate fields in both areas to minimise the possibility of total crop loss to either drought or flooding (Derman & Poultney, 1983). The more successful farmers market part of their produce and some grow crops such as cotton or tomatoes specifically for a cash return. Cash needs, however, are mostly met by remittances from migrant labours, 56 % of households being involved in urban labour (Derman & Poultney, 1983).

Derman and Poultney (1987) state that "the high incidence of labour migration has resulted in a strong local emphasis to gain better employment opportunities but education costs are high relative to family income and few families can afford to invest in education for all children". They also conclude that the sale of cattle may play an important role in providing the funds necessary for schooling and that "school children are dependent on non-school children for childwork", including herding.

Indigenous plants from both floodplain and forest areas are a source of building materials, foods and the bases for drinks (Krige, 1982; Cunningham, 1985; Buchan *et al.*, in press). Fishing contributes substantially to the provision of protein in the diet and involves almost all members of the family (Buchan *et al.*, in press; la Hausse de Lalouviere, P., pers. comm.).

No accurate data are available on the numbers of poultry and goats but this small stock apparently provides 15 - 25 % of local peoples' meat/protein intake (la Hausse de Lalouviere, in prep.). Cattle are owned by approximately 22 % of households and supply draught power, milk, meat and cash (from sales) and are also used as *lobolo* (dowry).

2.3 THE REGIONAL HISTORY OF ANIMAL HUSBANDRY

The first records of cattle in Maputaland are of Nguni stock brought south down the East coast of Africa by Iron Age agriculturalists between 200 and 600 AD (Robey, 1985; Opperman, 1986; Hall, 1980). Although no data are available for cattle numbers before 1850, it is unlikely that much livestock occurred in Maputaland prior to this date, since the area was never the centre of a civilisation, had endemic nagana and was known for its export of game products (Bruton, *et al.*, 1980).

Between 1850 and 1895 Havelock (1888) reported that cattle thrived in Maputaland despite disease but locals maintained low cattle numbers to avoid becoming an object of Zulu attacks. Wellington (1983) reported that few cattle existed in the region at this time and, on the basis of oral evidence recorded in 1897, Stuart concluded that there were "few or no cattle in Maputaland in the early days" (Webb & Wright, 1979).

Between 1895 and 1955 many cattle were lost to disease and wild animals. In 1897 the rinderpest epidemic reduced the number of cattle in the Ingwavuma district from 15 000 to 500 (Colenbrander, 1899; Foxon, 1899). Edington (1922) reported losses of up to 25 % of all cattle during nagana outbreaks in 1917, 1919 and 1920 and that disease completely excluded sheep and goats from Maputaland. Anti-nagana campaigns were launched throughout the first half of this century including the killing of 25 000 wildebeest in 1917 (Alfers, 1955) and 70 000 head of game in 1947 (Anon., 1947). Later campaigns involved fly trapping and spraying with D.D.T. (Alfers, 1947). By about 1960 only a few nuclei of infected areas, one of which was the Pongolo floodplain, still remained (Bruton *et al.*, 1980).

Brookes and Hurwitz (1957) noted that stocking density in Maputaland in the 1930's remained very low relative to the rest of Natal because of the high disease rate, while the Union of South Africa Agricultural census reports (1948 - 1954) show that approximately 5 % of cattle were lost annually with about 60 % of this being disease related and 30 % caused by wild animals. Despite these problems, cattle numbers increased in the first half of this century (Figure 2.1).

Cattle numbers continued to increase after 1950 (Figure 2.1) with the improvement of veterinary services. Felgate (1968) states that only a small proportion of men living near the floodplain owned cattle and that although cattle were important in other areas in Maputaland, "the river people are not traditional stock breeders". He attributed this to nagana and stated that with its recent eradication, cattle were doing exceptionally well. By 1970 the number of cattle in the area covered by this study had risen to 14 500 (Coke and Pott, 1970). Only 1 % of Maputaland is included in the Makatini study area (63 000 ha) but the area currently supports 19 000 cattle, about 12 % of the Maputaland total. A veterinary fence has been constructed to prevent the spread of disease from Mozambique (Figure 2.2) and in the last ten years disease has rarely affected more than 0.5 % of cattle at any one time (KwaZulu Government dip tank records).

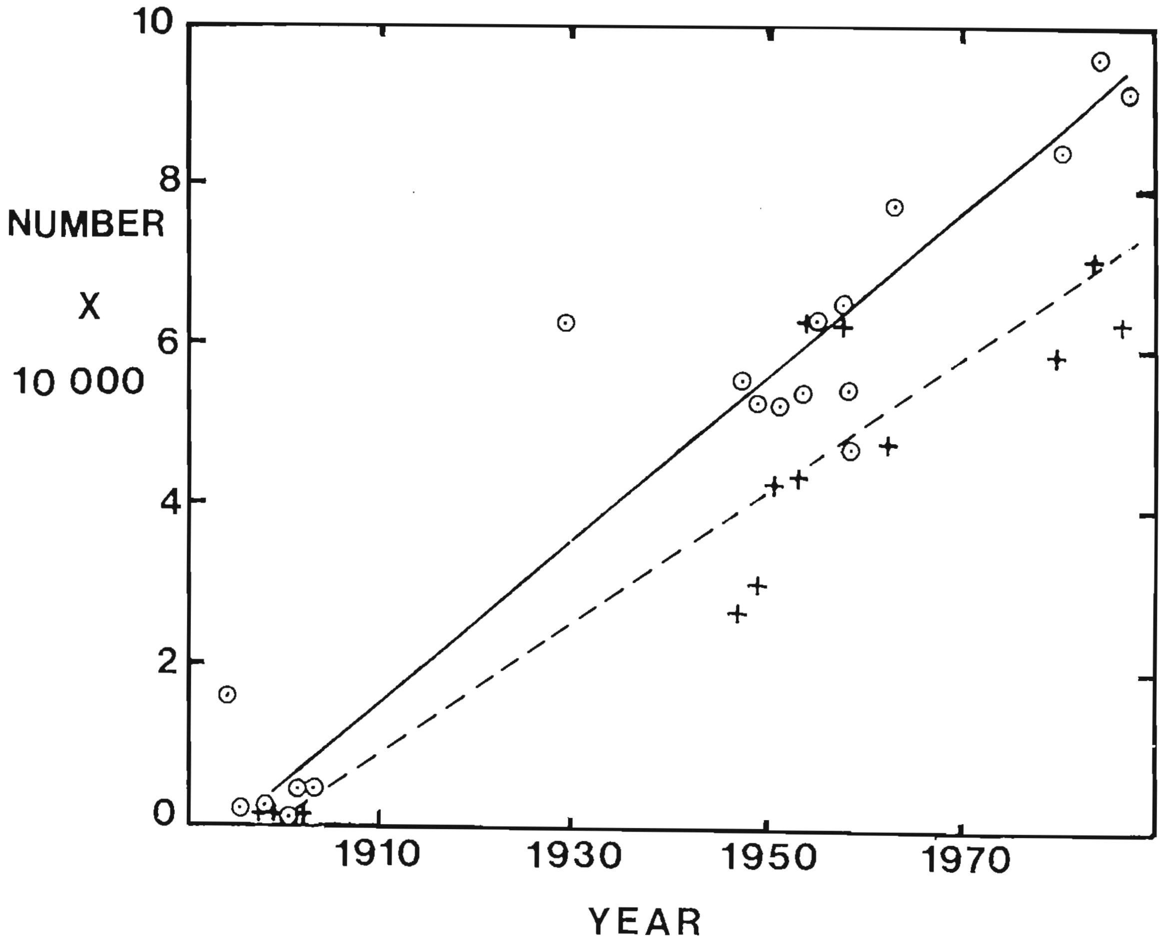

Figure 2.1 Cattle numbers in the Ingwavuma, ----, and Ubombo, - - -, districts. Lines are linear regressions for the least sum of squares difference. (Data from Colenbrander, 1899; 1901, Colony of Natal year books, 1901 - 1910, Union of South Africa statistical reports, 1930 - 1960, Natal regional survey, 1983, KwaZulu Department of Agriculture and Forestry annual reports, 1984 - 1985). *[1]

*[1]. Several inconsistencies are apparent in the data presented, but as the author had no means of checking the validity of data in the literature, all available values were included.

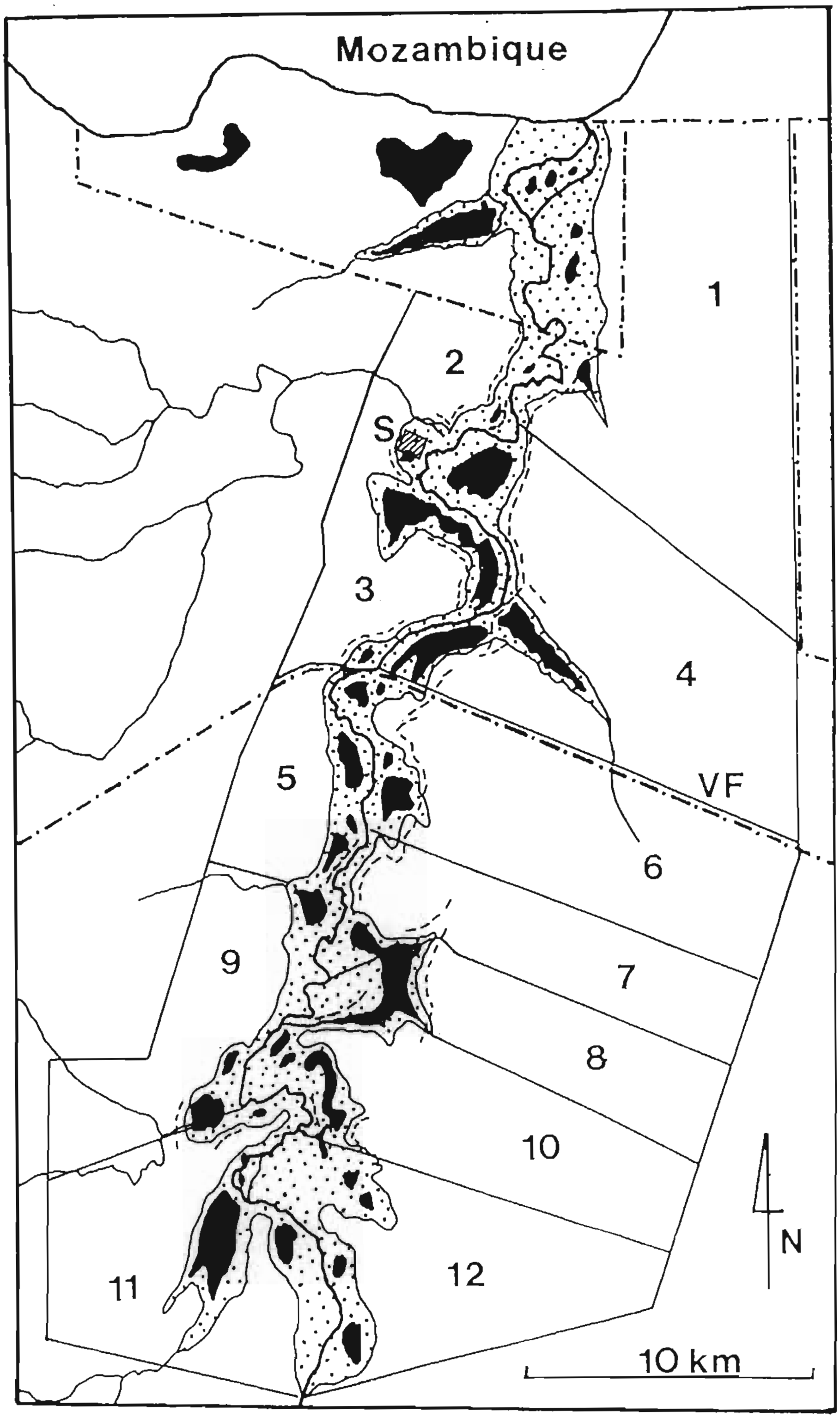

Figure 2.2 Pastoral "zones" on the Makatini flats, 1 - 12. Stock owners resident within each zone dip their stock together and rarely seek grazing outside the zone. Floodplain areas, ⁙ . Permanent water, ■. Wire fences, · — · — · . Wooden fences, - - -. VF = Veterinary fence. S = Sample site for *Echinochloa pyramidalis* grazing experiment (CHAPTER 7).

Braatvedt (1949), Bonsma *et al.* (1950) and Felgate (1968), all state that cattle in Maputaland were kept primarily for milk production and *lobolo* but also provided draught power and meat. It appears, therefore, that sale of cattle in Maputaland has become important only in the last 25 - 30 years. During this period at least eight regularly used sales yards, four of which service the Makatini flats, have been established. Cattle owners now take a strong interest in the sale of cattle (APPENDIX 1: 1.3 and 1.10), and market prices have increased by about 12 %/year since 1970 (Figure 2.3).

The first ploughs in the Maputaland area were a gift to a chief in 1910 (Union of South Africa, 1911). By 1986, 14 % of households owned ploughs (Derman & Poultney, 1987) and an estimated 12.5 % and 5.5 % possessed a draught team of two or four animals respectively (CHAPTER 3). These people are considered to be highly advantaged and are recognised specifically as "farmers" by local people (Derman & Poultney, 1987).

In summary, it appears that cattle ownership was, until about 20 - 25 years ago, a high risk activity practised by few inhabitants (Felgate, 1968). There was an alternative supply of animal products (for meat and trade) in the form of wildlife (Junod, 1927) and this was replaced by domestic stock (Pooley, 1980) after the eradication of nagana and the control of epidemic diseases such as rinderpest and foot-and-mouth. Cattle have become increasingly important to agriculture as a source of draught power.

2.4 DISCUSSION

Although cattle form an important part of the local socio-economy, people of the Makatini are not primarily pastoralists, but agriculturalists, in a partially "consumer based society" (Derman & Poultney, 1987). Pastoralism is just one of the activities in which people invest their capital and labour and pastoral management should be planned in this context.

The importance of understanding the socio-economic context in planning pastoral management on the Makatini can be illustrated by the following examples. Firstly, proposals to alter patterns of pasture use will have to be structured in accordance with existing and planned land use for agriculture. While the use of pasture areas, such as the floodplain, may be desirable,

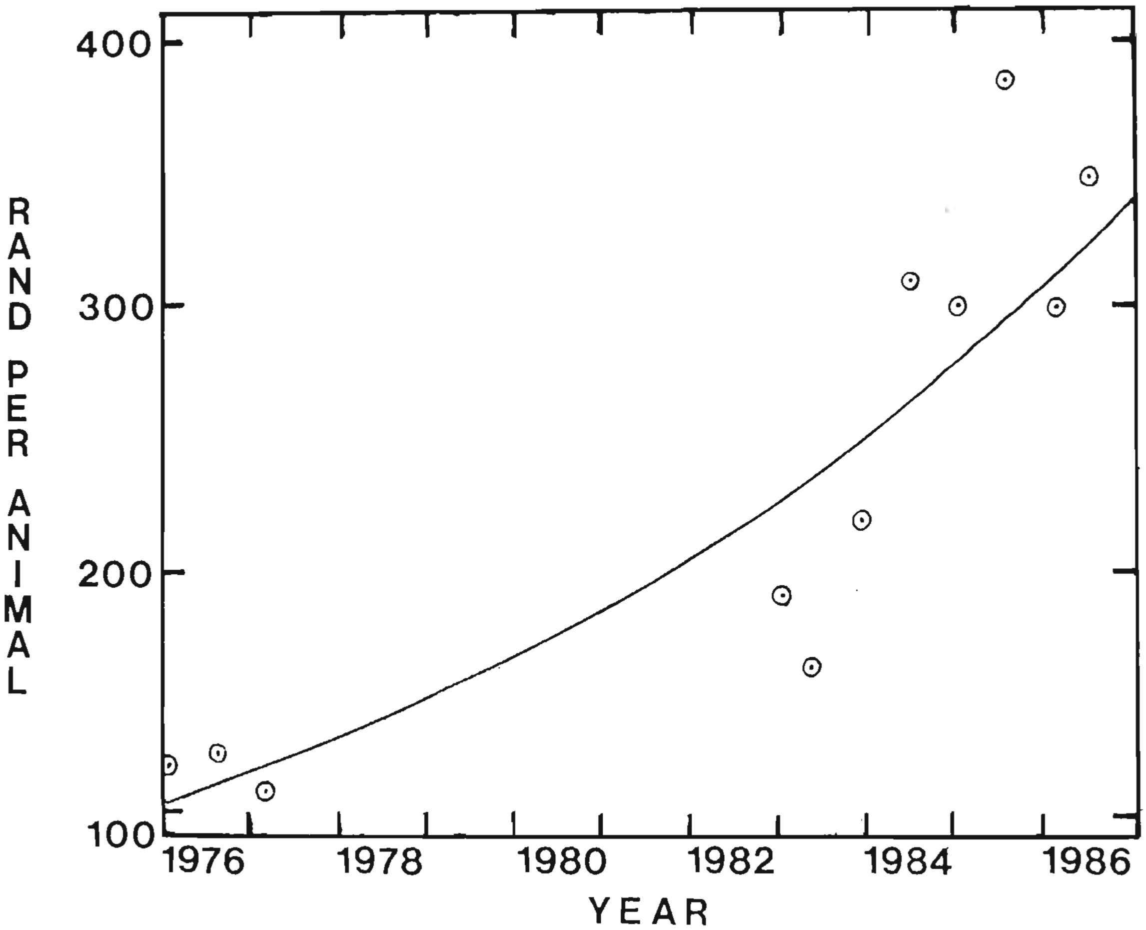

Figure 2.3 The mean price of all cattle sold in a month at the three sales yards that service the study area. (Data from KwaZulu stock sales record books Ubombo and Ingwavuma). The line is fitted for the least sum of squares difference using an exponential regression model.

where this interferes with agricultural activities it is unlikely to be acceptable to local people, particularly to those with no cattle (the majority of people). Secondly, bush clearing to increase pasture availability (Dye & Spear, 1982) is a pastoral management option that has been contemplated for areas of mixed bushveld (Cloete, C. Department of Development Aid pers. comm., 1986). In doing this the loss of building materials, wood fuel and plant species used as food or in drink and medicines will have to be considered.

When planning the management of livestock all values of utilities provided by cattle must be taken into account. Uys *et al.* (1985) estimated that revenue from cattle sales in Maputaland could be increased threefold through a "more efficient" marketing strategy without any improvement in basic management practices or increase in cattle numbers. This could be achieved by a change in herd composition involving a decline in the proportion of mature bulls and oxen from 26 % to 3 % (Uys *et al.*, 1985). The increased revenue from sales would be useful, but sale of potential draught cattle on the Makatini would mean a decline in a farmer's crop production, some of which may have been sold. Similarly, a marketing strategy designed to optimise beef animal offtake would be unsuitable for cattle owners who keep cattle primarily to provide milk.

From this description of the socio-economy of the Makatini it is clear that pastoralism is closely linked with activities such as agriculture and, through education, urban employment. The history of pastoralism shows that the strength of these links is continually changing. For example, where cattle were originally a source of animal products but were not used for ploughing and were probably rarely sold, these uses for cattle have now become more important. Changes in the pastoral system influence activities such as agriculture, and changes in agriculture influence how the pastoral system should be managed. For example, if tractors become more readily available the need for draught cattle would decline and a herd structure which optimises cattle offtake might become more acceptable. Because of these links pastoral management should not be isolated from other forms of development planning in the area. If recommendations for system manipulations made by external agencies are to be meaningful and acceptable to local cattle owners, these links must be considered but their importance must be kept in perspective, since only 22 % of household heads own cattle.

A history of low cattle numbers and a high incidence of disease is an indication that the Makatini has a high potential for epidemic. The currently high cattle numbers increase this potential and low disease rates can only be maintained if veterinary services remain effective (Haplin, 1987). With only two stock inspectors in the study area and eight dip attendants reporting to them, there are insufficient skilled staff to deal with epidemics (Ingwavuma region stock inspectors, pers. comm., 1986). The importance of effective vigilance for diseases such as foot-and-mouth, and a veterinary team capable of dealing with epidemic can only be understood in the light of the region's history of stock disease.

On the Makatini flats there is no long history of cattle ownership or traditional methods of dealing with drought or controlling stock/pasture interactions akin to those found in pastoral based societies elsewhere in Africa (Bassett, 1986; Oba & Lusigi, 1987; Hogg, 1987). The effectiveness of traditional management methods is well recognised by those who have attempted to increase productivity in African pastoral systems (Santoir, 1983; Jacobs, 1986; Boonzaier, 1987) but on the Makatini cattle populations have never been as large as they are now and the loss of cattle to disease or wild animals never so low. The lack of established pastoral traditions leaves cattle owners on the Makatini without a socially based structure, such as traditional nomadic migration patterns, to deal with stock population problems.

2.5 CONCLUSIONS

Three points have been illustrated in the above discussion. Firstly, that pasture management depends on the collective activities of cattle owners acting to fulfil personal needs in a dynamic socio-economic context. Secondly, that motivation for the manipulation of cattle numbers and herd structure is likely to be dictated by an owner's needs and his perception of the range of values that cattle can provide and his ability to access those benefits. Finally, that the livestock industry is closely linked to other aspects of the socio-economy and the desirability of cattle management options cannot be assessed without consideration of interactions between pastoralism and other socio-economic activities, particularly agriculture.

The significance of these observations is that they show that pastoralism must be managed not as a separate "industry" but as an integral component of the socio-economic system. Because of this, pastoral management planning must be closely linked with agricultural and regional planning.

Because it is the owner's perception of how he can best use cattle to fulfil his own socio-economic needs that dictates his actions, and socio-economic conditions are dynamic, continual liaison between cattle owners and regional planners is necessary.

As in other systems (Horowitz, 1979; Baker, 1980; Santoir, 1983) an understanding of socio-economic conditions is essential to providing relevant and acceptable suggestions for pastoral management on the Makatini but local traditions that deal with over-stocking problems in times of drought have had little time to become established.

CHAPTER 3

THE STRUCTURE OF THE PASTORAL SYSTEM ON THE MAKATINI FLATS

3.1 INTRODUCTION

Traditional African pastoral systems are generally described as being perpetually overstocked and this is considered to be the reason for their "low productivity" (Blair-Rains & Kassam, 1980; Crotty, 1980; Fowler, 1981; Sullivan *et al.*, 1981; Tapson & Rose, 1984; Uys *et al.*, 1985 and many others). Despite their frequent use, the terms "overstocked" and "low productivity" are rarely adequately defined.

Livestock productivity has been defined in terms of economic returns, live-weight gains and milk or draught power output (McDowell, 1985; Mentis, 1984). However, in African pastoral systems these parameters are often difficult to quantify and "low productivity" usually refers to poor cattle condition and the consequent high death and low birth rates of cattle in these systems relative to those in commercial systems.

Caughley (1981) points out that one's objectives in managing ungulates dictate how the system should be evaluated and, since objectives are value judgements expressing what benefits one wants, overstocking can only be determined in relation to specified objectives. "Productivity", characterised by stock condition, mortality and fecundity, is a major concern of African pastoral development programmes and, therefore, it is assumed that improved "productivity" is their objective. Thus, land can be judged to be overstocked when forage shortages result in poor animal condition, low birth rates and high death rates (Bembridge, 1979; Fowler, 1981; Sullivan *et al.*, 1981; Uys *et al.*, 1985).

Overstocking (as defined above) amounts to a reluctance among stock owners to remove stock from the land, even when animals are in poor condition, and various explanations for overstocking in African pastoral systems have been given. One suggestion is that cattle are kept as a long-term investment or "store of wealth" (Ayre-Smith, 1971; Webster & Wilson, 1980). Communal use of pastures but private ownership of stock is common in Africa (Webster & Wilson, 1980; Cross *et al.*, 1982; Marchot, 1983; Boonzaier, 1987) and this system structure is also frequently quoted as the primary determinant of perpetual overstocking, low productivity and diminished returns (Hardin, 1968; 1984; Mentis, 1984).

Hardin's interpretation of communal systems has been criticised as a simplification that ignores social and economic interactions that may affect the actions of peasant cattle owners by researchers who have investigated aspects of system structure such as herd size and composition (Palmer & Parsons, 1977; Low *et al.*, 1980; Sandford, 1982). The herd sizes required for cattle to provide various subsistence and commercial utilities have been calculated for traditional African systems (Bembridge, 1979; Behnke, 1982; Colvin, 1983). Estimates are based on household requirements for a daily milk supply, enough draught animals for cultivation (2 animals) or ploughing (4 animals) and surplus animals (1 - 2/year) for slaughter, sale, or use in social transactions. The size of the herd required to supply each utility depends on the herd's composition.

The questions that are addressed in this chapter are: Is the pastoral system on the Makatini communal and, therefore, subject to "the tragedy of the commons" ? Is the system unproductive ? Is perpetual overstocking the primary cause of low "productivity" ? Is offtake low and if so, how can this be explained ?

3.2 METHODS

The distribution of cattle in the study area was determined by interviewing stock men (methods CHAPTER 4) and during surveys of the patterns of pasture use (methods CHAPTER 6).

Birth and death rates and cattle condition were assessed so that "productivity" could be determined. Data on births and deaths were obtained from KwaZulu Government dip tank record books. Cattle condition was assessed at the end of the dry season, September, following a year of drought, 1985/1986 (rainfall = 0.75 times mean annual rainfall; data from Computer Centre for Water Research, Pietermaritzburg). Visual assessments of animal condition were made using the methods of MAFF (1978) and van Niekerk and Louw

(1980), (N = 1 900 animals = 10 % sample). All animals seen during walks along stratified transects through the study area were assessed.

The rates of cattle removal from private herds and from the region as a whole were assessed. Data on the transfer of cattle from private herds were obtained from KwaZulu dip tank record books. Data on the numbers of animals removed from the region were obtained from KwaZulu Government stock sales permits and record books.

The accuracy of some data in dip tank record books is questionable, and at most dips some of the records had been lost. Only data collected by dip attendants whom both the author and the regional stock inspector considered reliable, were used. Where dipping records contained anomalies, all records made on that day at that dip were excluded from the analysis. If < 3 of the 12 dips (i.e. 10 % of the stock) produced reliable records for the week all data for the week were excluded. All apparently reliable data for the period January 1983 to June 1986 were used in the assessment of offtake, birth and death rates. (N = 27 850 cattle years, or 1.5 years of data for all transactions, births and deaths in the study area).

The composition of herds was assessed at dipping. Cattle in the study area are dipped in 12 separate groups. Each group was considered a separate herd and the composition of 10 of these herds was assessed. Animals were placed into seven classes: bulls < 1year, bulls 1 - 2.5 years, mature bulls, oxen, heifers < 1 year, heifers 1 - 2.5 years, mature cows. Standard errors were calculated for each class from differences in the proportion of animals in the class in each of the 10 herds.

All cattle owners are registered at dip tanks and the numbers of animals they control is recorded at each dipping. The numbers of owners and cattle registered in the study area in February 1986 were used to determine the size of herds.

The herd sizes required to supply four basic utilities were calculated using the following equations:

$$NS = \frac{2}{[BR - DR]}$$

Where: NS = The herd size needed to supply two animals/year for sale or social exchange without a decline in herd size (units = animals/year)

BR = Birth rate (proportion of herd/year)

DR = Death rate (proportion of herd/year)

2 = The number of animals to be disposed of

$$ND = \frac{4}{[PB + PO]}$$

Where: ND = The herd size needed to span a team of draught animals (units = animals)

PB = The proportion of cattle holdings that are bulls (dimensionless)

PO = The proportion of cattle holdings that are oxen (dimensionless)

4 = The number of animals in a draught team

$$NMM = \frac{15}{PC \cdot PL \cdot MY}$$

Where: NMM = The herd size needed to supply a mean milk yield of 15 litres/herd/day

PC = The proportion of cattle holdings that are cows (dimensionless)

PL = The mean proportion of cows that are lactating

MY = The mean milk yield from lactating cows (litres/cow/day)

15 = The milk yield required (litres/day/herd)

$$NMA = \frac{4}{PC \cdot PML \cdot MMY}$$

Where: NMA = The herd size needed to supply an assured milk yield of 4 litres/herd/day

PC = The proportion of cattle holdings that are cows (dimensionless)

PML = The minimum proportion of cows that an owner can milk on the same day

MMY = The minimum milk yield from lactating cows (litres/cow/day)

4 = The milk yield needed (litres/herd/day)

The methods used to determine milk yields of stock are given in CHAPTER 5. Values for PL, MY, PML, and MMY were read from APPENDIX 2 (Figures A2.1 and A2.2).

3.3 RESULTS

3.3.1 Geographic distribution of cattle and pastures

There are no camps or paddocks used in pasture management in the study area, although some areas are fenced off to protect crops. Despite the lack of fences cattle rarely move out of the grazing areas loosely defined by tribal boundaries and the locality of dip tanks (Figure 2.2, p.21). While pastures are communally used in each "zone", zones can be considered separate systems. Stocking densities and the areas of different pasture types vary between the zones (Table 3.1) which means that overstocking problems can be restricted to specific zones.

3.3.2 Cattle productivity

The mean birth and death rates in the study area are 18.9 % and 9.8 % of cattle/year respectively. Herd size can, therefore, be expected to increase by 9.1 %/year if owners make no transactions (i.e. recruitment is 9.1 %/year). This is low compared with the 40 %/year achieved in some commercial beef units (Department of Economics and Marketing R.S.A., 1980).

At the end of the 1986 drought the condition assessment revealed that some animals were in a very poor condition, a few were fat but most were in a fair condition or better (Figure 3.1).

It is assumed that rainfall is a major determinant of forage availability and the effects of overstocking on "productivity", as characterised by birth and death rates, were assessed by comparing trends in rainfall with trends in birth and death rates over several years. A direct correlation is not meaningful because delays are expected between the times of low rainfall and food shortages, and between the time of food shortages and high birth and death rates.

Table 3.1 Areas and stocking densities in pastoral zones (Figure 2.2, p.21) on the Makatini flats. (AU = Animal Units = 1 mature cow).

DIP	UNIT No.	TOTAL AREA OF ZONE ha	FLOODPLAIN AREA ha	FLOODPLAIN/ TOTAL AREA RATIO	STOCKING DENSITY AU/ha
Nhlanjwane	1	7 750	178	0.023	0.16
Ndumu	2	2 627	366	0.139	0.38
Namanini A	3	3 820	1 111	0.291	0.13
Madlankunzi	4	7 575	833	0.110	0.13
Shemula	5	3 380	840	0.249	0.43
Tete A	6	6 449	267	0.041	0.14
Tete B	7	5 409	501	0.093	0.20
Tete C	8	4 357	454	0.104	0.23
Mzinyeni A	9	4 088	418	0.102	0.76
Sipondweni A	10	6 562	814	0.124	0.69
Mzinyeni B	11	4 675	534	0.114	0.59
Sipondweni B	12	7 068	1 112	0.157	0.19

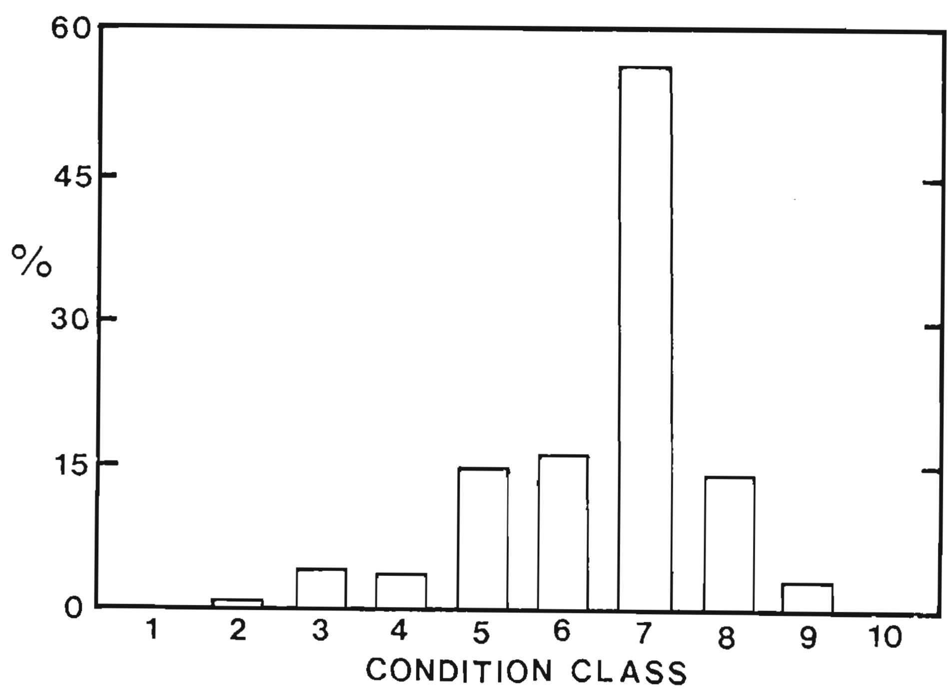

Figure 3.1 The proportion of cattle on the Makatini flats in September 1986 in each of ten condition score classes (N = 2 000 cattle). 1 - 2 = very thin; 3 - 4 = thin; 5 = lean/fair; 6 = good; 7 - 8 = fat; 9 - 10 = very fat.

Rainfall in the 1980/1981 season was approximately average for the area. This was followed by two years of drought, the 1982/1983 season being the most severe (Figure 3.2). Rainfall was high in the 1983/1984 and 1984/1985 seasons but low again in 1985/1986.

The only major peak in death rate between 1983 and 1986 occurred at the end of 1983 (Figure 3.3A), when the effects of drought would be expected to be most severe (Figure 3.2). Death rate remained between 10 and 20 %/year for most of 1984 which seems unusually high considering that rainfall was good in 1984 (Figure 3.2), and in early 1983 and during 1985 and 1986 the death rate was below 10 %/year (Figure 3.3A). However, it was established that because of the extremely large number of deaths in the 1983 drought, deaths that occurred between August 1983 and March 1984 were still being recorded until the end of 1984 (KwaZulu Government dip tank officials, pers. comm., 1985). Death rates did not show a clear seasonal trend and appear to have been unrelated to rainfall between 1983 and 1986 except during the drought of 1983 (Figures 3.2 and 3.3A).

In 1983, 1984 and 1986 birth rate in the study area showed a seasonal trend, being highest in January and declining until about the end of October (Figure 3.3B). In 1985 birth rate remained relatively constant being low in the first half, and high in the second half of the year relative to birth rates in 1983, 1984 and 1986 (Figure 3.3B). This could be explained as a reflection of poor animal condition in late 1983 and early 1984 but provides little evidence to support the thesis that birth rate was markedly reduced by the 1983 drought.

3.3.3 Disposal of cattle

Cattle owners on the Makatini dispose of 18 % of their cattle holdings each year, which is double the recruitment rate (3.3.2). Eighty one percent of these animals are used in social exchange and only 19 % are sold at markets. If the region is looked at as a whole, only 4 % of cattle holdings are sold annually and, since 1 % are purchased, the net sale of cattle is 3 % of holdings/year.

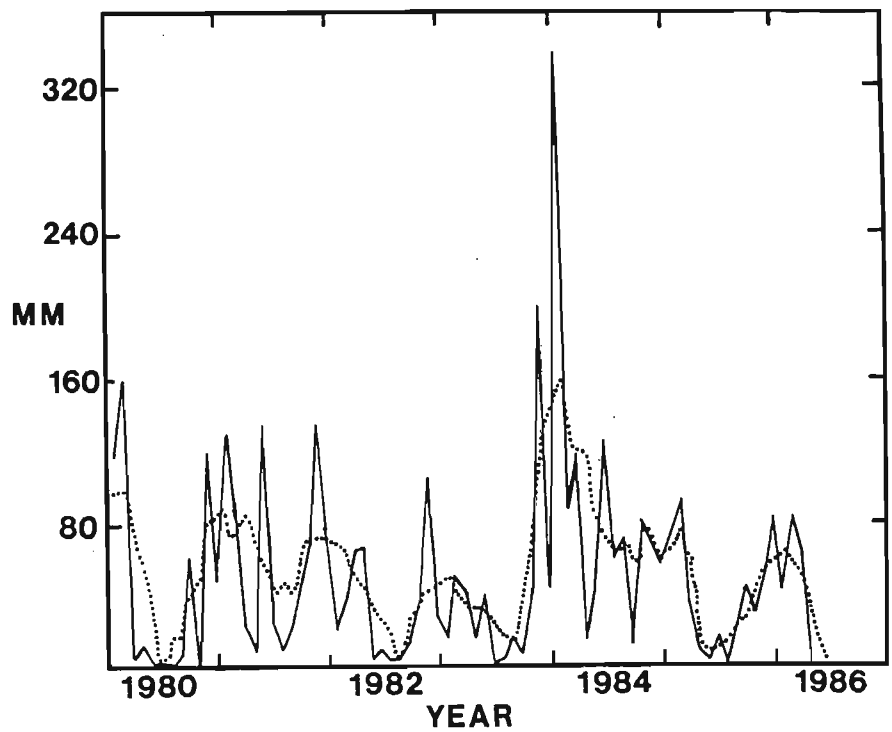

Figure 3.2 Monthly rainfall on the Makatini flats. ——— , actual values, ·····, a simple running mean of three data points. Note: rainfall was low in the 1981/1982 and 1982/1983 seasons causing severe drought conditions in late 1983, and in 1985/1986 causing drought in late 1986.

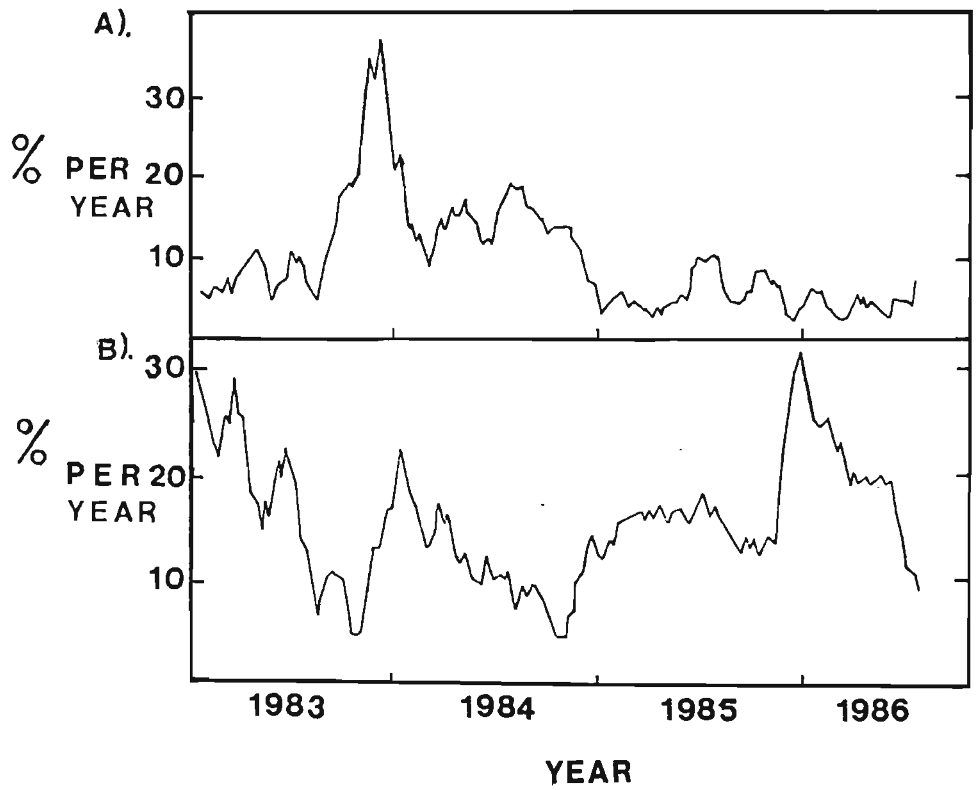

Figure 3.3 Birth rate, (A) and death rate, (B) for cattle on the Makatini flats. Units are percent of regional herd/year.

To understand how cattle are disposed of it is necessary to establish a budget of cattle acquisition and loss for both privately owned herds and the study area as a whole. If it is assumed that cattle owners gain as many animals through social exchange as they lose, the gross increase in their herd will be 39 %/year. Of this, 3 % will be from purchases made outside the area, 48 % from social exchanges and 49 % will be new calves. The cattle owner will lose 28 % of his holdings of which 12 % will be disposed of through markets, 35 % will be deaths and 53 % will be social exchanges. Approximately 61 % of social exchanges are made between cattle owners living in the same zone (Figure 2.2, p.21) and 39 % between owners from different zones of the study area. The net increase in an individual's cattle holdings is, on average, 6 %/year.

For the study area as a whole 5 % of increases are in the form of purchases of cattle from outside the area and 95 % are births. Together these sources of animals account for a gross increase of 20 % of cattle holdings annually. Total losses are 14 %, of which 74 % are through deaths and only 26 % through sale at markets. As for privately owned herds, the net increase in cattle holdings is 6 %/year.

These results show that cattle owners are not reluctant to dispose of their stock and readily exchange cattle at a local level, but that few animals leave the study area through markets.

3.3.4 Herd composition

Herd composition for the Makatini flats is given in Figure 3.4. The proportion of potentially active breeding females (49 %) is close to that considered optimal in commercial beef herds (Department of Economics and Marketing R.S.A., 1980). The ratio of cows : bulls is 8.7 : 1 and close to the ratio of 10 : 1 considered optimal for breeding purposes in the Maputaland region (Uys *et al.*, 1985). The high proportion of oxen (second only to cows) is an indication of the importance attached to the ownership of draught stock.

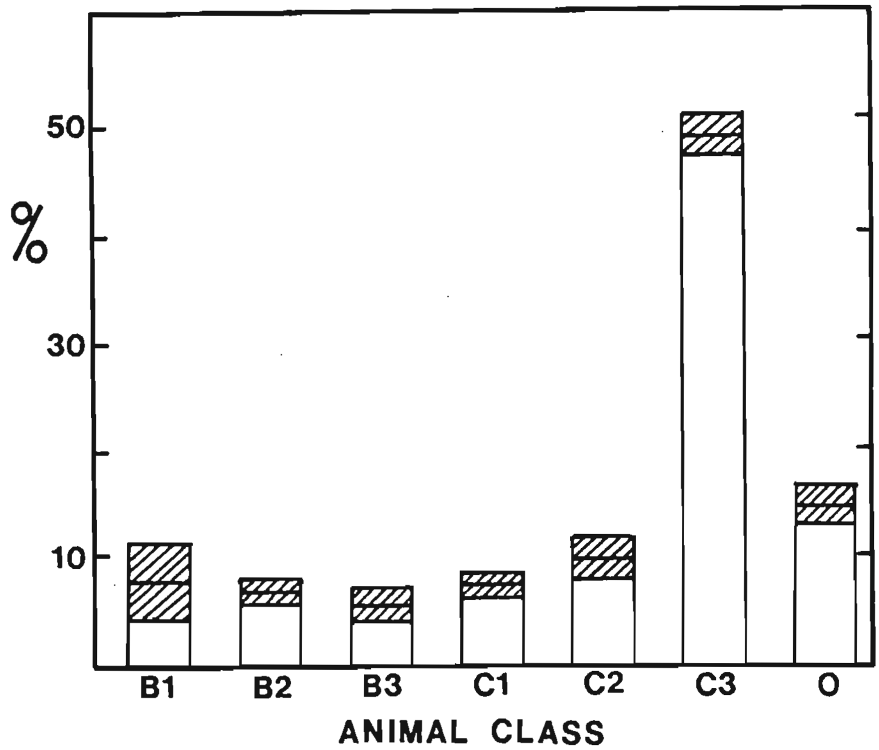

Figure 3.4 The composition of cattle herds on the Makatini flats. B = Bull, C = Cow, O = Ox, 1 = age < 1 year, 2 = 1 - 2.5 years, 3 = < 2.5 years. N = 8 zones (Figure 2.2, p.21). Shading = 2x s.e. Units are percent of total stock holdings.

Table 3.2 Data used in the calculation of the minimum herd size needed to supply owners with: two surplus animals annually for sale or social exchange; a draught team of four animals; a mean yield of 15 litres, and an assured yield of 4 litres of milk/herd/day. Data source: 1 = KwaZulu Government dip tank record books; 2 = Figure 3.4, p.36; 3 = APPENDIX 2, Figure A2.1B; 4 = APPENDIX 2, Figure A2.1A.

DATA TYPE	VALUE USED	UNITS	DATA SOURCE
Birth rate	0.189	Proportion/year	1
Death rate	0.098	Proportion/year	1
Herd composition (Bulls)	0.056	Proportion/Dimensionless	2
Herd composition (Oxen)	0.149	Proportion/Dimensionless	2
Herd composition (Cows)	0.486	Proportion/Dimensionless	2
Mean proportion of cows milked daily	0.491	Dimensionless	3
Minimum proportion of cows milked daily	0.182	Dimensionless	3
Mean milk yield	3.63	litres/lactating cow/day	4
Mean minimum milk yield	2.5	litres/lactating cow/day	4

3.3.5 Herd size

Taking cognizance of herd composition, birth and death rates and milk yields, a household on the Makatini needs 22 animals to allow for the disposal of two animals annually through sales or social exchange; 20 animals to span a draught team of four and 18 animals to provide a mean daily milk supply of 15 litres or an assured supply of 4 litres of milk/day. Data used in the calculation of these values are given in Table 3.2 .

One thousand nine hundred and sixty nine cattle owners and 19 300 cattle are registered in the 12 diptank "zones" in the study area. This gives a mean personal or household herd size of 9.8 head. Herd size distribution is negatively skewed (Figure 3.5A) so that only 21 % of owners have herds that can supply the basic utilities described above and only 50 % of cattle holdings fall into this category (Figure 3.5B).

3.4 DISCUSSION

3.4.1 The distribution of cattle

On large African floodplains stock are generally moved over large distances (> 50 km) to reach pastures (Bassett, 1986; Drijver & Marchand, 1986) and individual herds have access to large areas of pasture. Because the common resource base is large, questions relating to cattle/pasture interactions such as "is the area overstocked ?" can be addressed at this scale. However, on the Makatini cattle are restricted to specific zones (Figure 2.2, p.21) and only cattle in a particular zone share a common pastoral resource. This means that cattle/pasture interactions can be expected to differ over short distances (< 20 km) and the results presented in Table 3.1 show that these differences are marked. The reason for the difference between the Makatini and other floodplains is that Makatini cattle owners are not primarily pastoralists and are not nomadic. The significance of the difference is that it shows that management of the cattle/pasture interaction should be carried out at a scale appropriate to the system of pasture use.

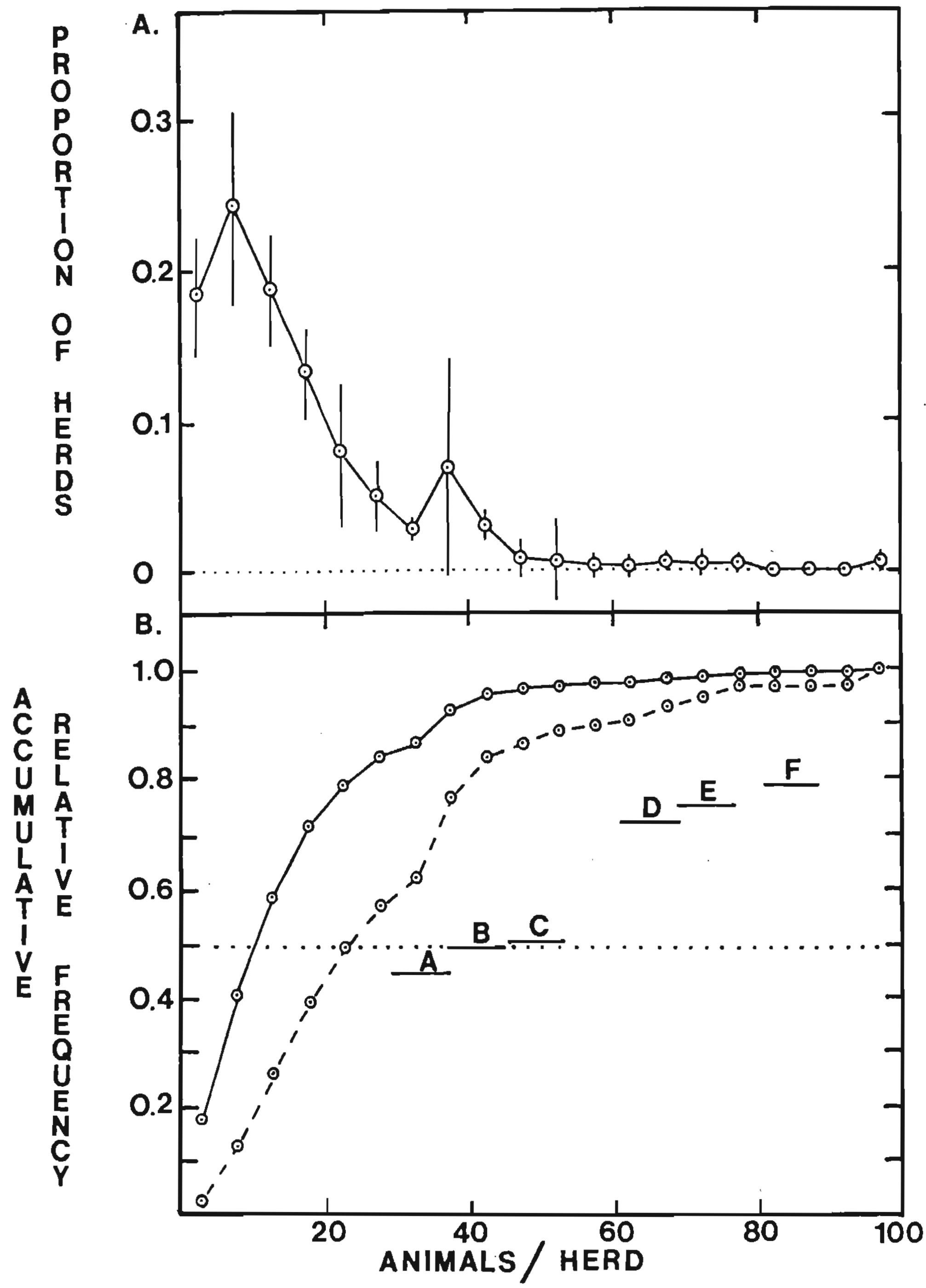

Figure 3.5 A. The proportion of cattle herds on the Makatini flats that fall within each of 20 herd size classes. Classes are of equal size (1 - 5, 6 - 10 etc.). Vertical lines are 2x s.e.. N = 10 zones (Figure 2.2,p.21). N = 1 465 herds.
B. The accumulative relative frequency of herds, ——, and stock holdings within herds, - - -, plotted against herd size. Letters indicate the proportion of herds that can supply the following utilities: A, an assured and mean milk yield of 2 and 7.5 litres/day respectively; B, 1 animal/year for sale or social use; C, 2 draught animals; D, an assured and mean milk yield of 4 litres/day and 15 litres/day respectively; E, 4 draught animals; F, 2 surplus animals/year. ···· = mean herd size.

Whilst it may be acceptable to manage a large system with nomadic pastoralists as a single unit with respect to stock/pasture interactions, pasture management must be approached on a much smaller scale in areas where cattle owners control their animals from a single homestead. On the Makatini the individuality of "zones" means that the management input required for each area may be different and that they should be dealt with as separate units. Government or institutional schemes for the improvement of cattle productivity are commonly implemented on a large (regional or national) scale and are based on general conclusions about overstocking and productivity (Tapson & Rose, 1984; Hundleby *et al.*, 1986; Hogg, 1987).

3.4.2 Productivity

The Makatini pastoral system has a recruitment rate (birth rate minus death rate) well below that of well managed commercial beef production systems (Department of Economics and Marketing R.S.A., 1980) and might be considered unproductive because of this. However, before the system is classified unproductive, a discussion of the reasons for low recruitment rate is necessary.

At present there is little evidence to show that recruitment rate is low because of overstocking. Only at the end of two years of drought was there any indication that birth and death rates were being affected by a lack of forage, and after one year (1985/1986) of low rainfall most cattle were still in good condition. Cattle are clearly not kept "at starvation point" as is reported for other systems (Tapson & Rose, 1984).

Herd composition cannot be considered to be the reason for low productivity as the proportion of cows in the herd is near optimal for commercial units (Department of Economics and Marketing R.S.A., 1980) and Nguni are not of an inferior breed, having been shown to be competitive over a wide range of performance parameters (Ramsey, 1985).

Poor animal health could be expected on the Makatini as veterinary services are rarely available and many cattle owners cannot afford medication (APPENDIX 1: 3.5). The calving rate (0.4 births/cow/year) is below that of commercial systems under similar conditions (0.6 births/cow/year; Vorster, 1964) and this leads to the suggestion that disease or parasite infestations may be reducing fecundity and contributing to low productivity.

Low recruitment rate relative to commercial systems occurs primarily because death rates are relatively high. There are two possible explanations for this. Firstly, in commercial systems stock are usually sold once they have been "grown out" (Scholtz & Lombard, 1984) whereas on the Makatini animals are kept in the system longer because they have subsistence values as well (e.g. draught power and *lobolo*). Secondly, home slaughterings are recorded as deaths and although these are illegal for health reasons and are uncommon except for dying animals (APPENDIX 1: 1.4) they do occur on ceremonial occasions (Buchan *et al.*, in press). The importance of these two factors has not been assessed but it is reasonable to assume that they contribute to the high death rate.

Although disease may be causing some reduction in productivity, it seems that the grounds for classifying the system "unproductive" are questionable and may arise simply because of the differences in the objectives of commercial beef farmers and subsistence pastoralists and a lack of veterinary services. As stated by Caughley (1981), "pastoral systems should only be assessed in terms of their own objectives", and in this case even a comparison of productivity on the basis of recruitment rate appears to have been unjustifiable. What is required is an assessment of the productivity of the system in terms of the utilities that cattle owners receive (CHAPTER 5).

3.4.3 Offtake

The use of the pastures of the Makatini as commonage makes the system potentially subject to "the tragedy of the commons" (Hardin, 1984). However, the problems that Hardin describes only arise when there is no cost for, or control over, the use of resources and the demand for use of the resource exceeds what can be supplied. This means that while the syndrome does not apply to the Makatini at present it can only be avoided if a system of control of pasture use is developed on the Makatini within the next few years.

As a result of a low offtake rate (less than half the recruitment rate) on the Makatini, cattle numbers can be expected to double every twelve years. The drought in 1983 showed that current stocking densities cannot be supported during severe droughts and an analysis of the long-term rainfall data for the area (data from C.C.W.R., University of Natal) shows that two-year periods with less rainfall than that which fell during the 1982/1983 drought have occurred at least eight times in the last 60 years. This is strong evidence to suggest that if offtake from the system is not increased "productivity" will be adversely affected by overstocking. Before recommendations can be made about how to increase offtake it is necessary to determine why offtake is so low.

Despite the low, net export of cattle from the Makatini there is a high degree of exchange of cattle at a local level. Use of cattle for social exchanges such as *lobolo* is more important than the sale of cattle at markets, a conclusion which has also been made in other southern African studies (Bembridge, 1979; Sandford, 1982), and is in accordance with the more general interpretation that the subsistence and social value of cattle in traditional systems exceeds its commercial value (Danckwerts, 1974; Fielder, 1973; Colvin, 1983). As long as the animals remain more valuable in the system than at the market there is no incentive to sell more cattle. This in itself is an adequate explanation for a low offtake from subsistence systems. If overstocking should occur it could be explained by the disposal of most cattle within the communal system (zone or region), which does not result in a reduction in the number of animals on the land.

The importance of the analysis of herd size and structure is that it provides an indication of what utilities can be supplied. It is clear that most herds are too small for owners to make full use of the utilities their cattle could provide. For example, 40 % of potential draught cattle belong to owners with less than four draught animals and 20 % to owners with less than two. This means that much of the draught potential of cattle is unused despite a local shortage of ploughing facilities (Derman & Poultney, 1987). Improved animal condition and productivity would reduce the size of herds needed to supply the same utilities, but small herd size can only be expected to increase the motivation for cattle acquisition or retention, and this can be expected to aggravate any overstocking problems and to reduce productivity.

The discussion of reasons for low cattle offtake on the Makatini can be summarised as follows:

a) In terms of short-term forage production capability the Makatini flats do not appear to be overstocked and, therefore, cattle owners can be expected to capitalise on the use of pastures by increasing their cattle holdings.

b) Low offtake is not due to a reluctance to dispose of cattle but occurs because cattle are disposed of within the communal system.

c) Disposal of cattle within the system or retention of cattle appears to occur because the value of benefits received from cattle is greater than that received if animals are sold at the market.

d) Most cattle owners would be able to make better use of their stock holdings if they increased their personal herd size, which provides an added incentive not to sell cattle.

Although some of this discussion is speculative, it serves to illustrate that herd size influences the utility value of cattle and has the potential to influence the way in which the system is stocked. Low offtake is clearly not simply the result of a desire to "store wealth" (Webster & Wilson, 1980) since cattle owners are getting rid of animals from their private herds. The criticism that Hardin's theory is a simplification (Palmer & Parsons, 1977; Low *et al.*, 1980; Sandford, 1983) appears valid, because other reasons for low offtake are easily identified. However, this does not alter the fact that pasture use is essentially unrestricted and owners can manipulate herds on the basis of their personal motivations and objectives without being answerable to other pasture users, or that "the tragedy of the commons" does not apply to localised areas of the Makatini flats.

3.5 CONCLUSIONS

Consideration of the scale at which pasture resource use occurs is an important aspect of the management of pasture/animal interactions and this appears to have been ignored in some livestock development programmes. Generalisations about "overstocking" may not be valid in terms of the objectives of cattle owners and it is important that systems be evaluated in relation to these objectives. If this does not occur African pastoral systems are likely to be classified as "unproductive" because they have a low offtake (Blair-Rains & Kassam, 1980; Tapson & Rose, 1984; Uys *et al.*, 1985) despite the fact that stock sales are not necessarily the primary reason for cattle being kept.

From this discussion on cattle disposal two important points emerge: firstly, the value of cattle cannot be determined without understanding the importance of the subsistence utilities provided and secondly, the value of utilities relative to each other influences the way in which the system is stocked and managed. This means that if proposals are to be made for the management of African pastoral systems it is important to identify cattle owner objectives (CHAPTER 4) and to determine the value of different utilities in the local context (CHAPTER 5).

CHAPTER 4

LOCAL PERCEPTIONS OF STOCK VALUE AND MANAGEMENT

4.1 INTRODUCTION

There are many publications in which the reasons for the failure of African pastoral development programmes are discussed, and most of these include comments on the development planners' lack of understanding of the needs of the stock owners concerned (Baker, 1980; Ayuko, 1981; Perrier & Craig, 1983; Deng, 1984; Boonzaier, 1987).

Frankenberger (1986) states that there is a need to consider the broader environmental context in which resource allocation is taking place and that system management in accordance with pastoralists' own needs and perceptions promotes only short-term goal orientation regarding livestock investment. He suggests that short- and long-term perspectives be combined by considering needs at household and co-operative levels. The failure of stock owners to recognise needs at a community level could be considered to form the basis of the "tragedy of the commons" theory (Hardin, 1968) which suggests that members of a community are "destined for ruin" because they pursue personal goals and ignore public or community interests (Hardin, 1984). To avoid management input at an inappropriate level in Malian pastoral systems, Franke (1984) suggests the development of small-scale co-operatives. Others, while acknowledging the importance of cattle owners' personal needs, state that African pastoral systems need management on a larger scale than private herds (Baker, 1980; Awogbade, 1982; Deng, 1984; Frankenberger, 1986). The importance of cattle owner perceptions in this issue is that before management at a community or co-operative level can be established stock owners must consider this management both necessary and feasible.

The socio-economic context and history discussed in CHAPTER 2, and the structure of the system discussed in CHAPTER 3, provide a basis for an improved understanding of the motivations behind cattle owner activity and of what management options/suggestions would be relevant and acceptable within the local social context. However, the issues discussed in those chapters are theoretical and their significance can only be assessed within the context of local perceptions because it is the perception of how cattle owners can best fulfil their own needs which ultimately dictates how cattle and pastoral resources will be managed (Tapson & Rose, 1984; Derman & Poultney, 1987). In this Chapter cattle owner perceptions of system management are assessed so that the way in which they stock the system can be understood and their priorities identified. The importance of Makatini cattle owners' perceptions to the development of a livestock management plan is discussed.

The issues regarding the perceptions of cattle owners raised here and in the discussion in CHAPTERS 2 and 3 can be addressed by answering the following questions:

a) How does the cattle owner perceive the benefits of stock ownership ?

b) How do cattle owners perceive the relationship between pastoralism and other activities such as agriculture ?

c) What management issues do cattle owners perceive as being important for the maintenance and improvement of the returns they receive from cattle ?

4.2 METHODS

The questions outlined above were addressed using three types of interview. Firstly, personal interviews were conducted with 2 % of cattle owners, (Belson, 1981) with responses recorded by the questioner on a structured schedule (APPENDIX 1). Advantages of this method are that a structure makes quantitative analysis possible, the interview is flexible, answers are spontaneous (Sudman & Bradburn, 1982) and the interviewer can rephrase or adjust questions where necessary (Selltitz *et al.*, 1961). Limitations include the dependence on the interviewee's memory (Murphy & Sprey, 1982) and the possibility of intentional or unintentional bias (Sudman & Bradburn, 1982).

Secondly, semiformal meetings were held with key personnel; cattle owners, dip tank committees, dip attendants and cattle inspectors for qualitative assessment (N = 8 meetings; the number of attendants per meeting ranged from 7 to 30). Since cattle owners may be reluctant to discuss their personal cattle management practices and the benefits they personally receive from cattle, this technique provides a good cross reference for information obtained in private interviews by allowing stockmen to give their views on management and benefits without having to answer personal questions (Tapson & Rose, 1984).

Finally, informal discussions were held with groups of herd boys (N = 60 groups of 4 to 10 herders). This qualitative information provides a cross reference for information about the day to day management of cattle and the rationale behind herding practices.

4.3 RESULTS

The information collected from interviews and discussions is largely qualitative and consists of people's opinions. Due to the complexity of the results, quantitative data from personal interviews with cattle owners are presented in the form of questions and answers in APPENDIX 1, and only the author's conclusions about the three questions given above (4.1) are presented in the text.

4.3.1 The benefits of cattle ownership

Makatini cattle provide a wide range of utilities including milk, draught, *lobolo*, cash, and meat (APPENDIX 1: 1). Milk is probably the most important resource, but cattle owners do not see utilities as separate entities (APPENDIX 1: 1.1). Tapson and Rose (1984) in their general KwaZulu cattle survey suggest that owners regard stock as "working assets". This appears to apply to the Makatini where owners are not reluctant to dispose of stock to fulfil specific needs, but are aware of the loss of utility values through small herd size (APPENDIX 1: 1 and 3).

4.3.2 The relationship between pastoralism and other socio-economic activities

The relationship between agriculture and pastoralism has both positive and negative aspects. Draught is in short supply and people see the acquisition of a draught team as a means of greatly improving their returns from agriculture (APPENDIX 1: 1.5 - 1.8; Derman & Poultney, 1987). Cattle are also seen as a source of capital for investment in agriculture (APPENDIX 1: 1.3 and 1.10). The negative aspect is the perception of a serious conflict between pastoralism and agriculture on the floodplain (APPENDIX 1: 2). There is an awareness that the conflict is intensifying and that its primary cause is the increase in human population (APPENDIX 1: 2.6). The need to send children to school is seen as a factor contributing to crop losses caused by cattle. Resolution of the problem is being sought through the improvement of fencing (APPENDIX 1: 2.7).

Cattle provide for a wide variety of cash needs including school fees (APPENDIX 1: 1.3 and 1.10; Derman & Poultney, 1987).

4.3.3 Cattle owner management perspectives

Manipulation of herd numbers and structure is the prerogative of the individual owner and is dictated by his personal/family needs. However, it is accepted that management of the system's infrastructure is only possible through collective decision making (APPENDIX 1: 3.2) and the concept of cattle management at a community level is well established. In addition to communally building fences to control cattle movement (APPENDIX 1: 2.7), cattle owners co-operate to run dips (some groups jointly buying pumps to fill dips) and in the purchase of veterinary supplies. Despite their acknowledgement of a need for management at a community level, cattle owners recognise the fact that their objectives and priorities in the development of an infrastructure to assist in cattle management are extremely varied. The variation is seen mostly as a result of the positioning of owners' homesteads relative to the existing facilities such as dips, water points and sales yards.

Intensification of the problems of overstocking is recognised and this is seen as an important factor in reducing the benefits received from cattle, especially with respect to draught (APPENDIX 1: 1.7 and 3.2). However, this problem is not identified by cattle owners as a management issue and is seen as a consequence of exclusion from land or of the increasing human population (APPENDIX 1: 3.3 and 3.4) rather than because people own too many cattle. Cattle owners consider other socio-economic activities, particularly agriculture, as part of the stock management question (APPENDIX 1: 3).

Although the risk of epidemic in the area is high and the infrastructure to deal with it probably inadequate (CHAPTER 2), cattle owners do not appear to recognise the importance of the need to improve the veterinary service infrastructure or at least do not regard it as a pressing management issue (APPENDIX 1: 3).

4.4 DISCUSSION

It is important to note that cattle owners see cattle as a multiple-use resource and prefer not to identify utilities individually because this means that attempts to manage the system in order to capitalise on returns from one utility will meet with opposition. One of the primary goals of government or institutional schemes is to increase output from marketable utilities such as animal sales (De Glas & Venema, 1982; Tapson & Rose, 1984; Uys *et al.*, 1985) but the value of subsistence utilities generally exceeds that of the market value of cattle (CHAPTER 3). This difference in objectives has been recognised in a variety of ways as being the reason for livestock development scheme failure (Baker, 1980; Ayuko, 1981; De Glas & Venema, 1982; Perrier & Craig, 1983; Deng, 1985). The Makatini system is no exception with respect to how cattle owners perceive utilities and it is important that planners take cognizance of the needs for milk, draught, a cash return from sales and the importance of cattle in social exchange in the development of any government or institutional pastoral management scheme for the area.

The fact that cattle owners answer questions about pastoral management in terms of their agricultural activities indicates that the interaction between agriculture and pastoralism is a key issue in the success of any cattle development programme. Because this interaction is what cattle owners consider important, management initiatives should address the problems of the conflict over land for pastoral and agricultural purposes and ways of enhancing positive aspects of the cattle/agriculture interaction (ploughing capabilities) should be sought.

Cattle owners give precedence to agricultural needs whenever a conflict for land use arises. Thus, development of the pastoral system must be done within the constraints defined by the development of agriculture. Loss of some of the returns from cattle will probably be acceptable on the Makatini if this is the result of the improvement of cattle owners' personal agricultural output. In systems where pastoralists and agriculturalists belong to different population groups this is not the case. In Ethiopia and Mali schemes to improve agricultural productivity through irrigation on or near floodplains have had disastrous consequences for pastoralists who use floodplain pastures (Kloos, 1982; Marty, 1983).

The diversity of needs identified by cattle owners and their perception of the reason for this as the positioning of homesteads with respect to facilities has two important implications for planning the development of an infrastructure of facilities such as sales yards, dips, water points and fencing. Firstly, planning must be done on a small scale to ensure that the most important needs of cattle owners are met and secondly, a cattle development scheme should be flexible enough to address a wide range of problems.

The most common need of cattle owners is that for more sales yards. This is particularly important in the light of the concern over the low offtake on the Makatini. It shows that cattle owners would probably increase their offtake if they were not hampered by the lack of marketing facilities. Tapson and Rose (1984) recognise this as one of the reasons for low offtake in KwaZulu in general and propose the use of "mobile buying units" to alleviate the problem. Implementation of this scheme would assist cattle owners in meeting their immediate needs and would also contribute to the prevention of overstocking problems in the area in the long-term.

The co-operation of cattle owners in management at a community level and their perception that problems relating to the use of pastures can be solved by participation in group projects such as the building of fences, provides some hope for the development of a management strategy to prevent "the tragedy of the commons" from becoming a reality on the Makatini. What cattle owners do not believe, however, is that it is within their capability to prevent overstocking problems.

Many suggestions have been made as to how to prevent perpetual overstocking: changed land tenure through establishing a communal land company (Reynolds, 1977;1981) or appropriation of communal grazing to group company or individual land (Crotty, 1980); stock control by quota (Sandford, 1982; Jerve, 1981); cattle banks (Southey, 1982); and taxes on pasture use (Crotty, 1983). However, as yet no generally accepted means of preventing the "tragedy of the commons" in African pastoral systems has been developed (Tapson & Rose, 1984; Mentis, 1984). All published suggestions have been developed by people who are not facing the problem themselves and it is suggested that cattle owners of the Makatini are in a better position to develop their own solutions to local overstocking problems than researchers. The Makatini is experiencing overstocking problems for the first time. Stock owners understand community level participation as a means of solving common cattle management problems and they understand that overstocking is linked to a human population increase and not just the year's rainfall. If it is accepted that cattle owners are in the best position to solve the problems, what is required of a development programme are extension services which include discussion of overstocking, the "tragedy of the commons" problem and the different proposals that have been made to solve these problems in other areas.

4.5 CONCLUSIONS

As has been found in other studies of African pastoral systems, the understanding of stock owners' perspectives on the Makatini is important in determining how the development of pastoralism should be approached. A policy that takes account of the value of the range of utilities provided by cattle is needed. The policy should be made in conjunction with plans for agricultural development and planners should concentrate on finding ways of reducing the conflict between pastoral and agricultural use of land, bearing in mind that requirements for agricultural land take precedence over the need for pastures.

The diversity of needs and their occurrence because of the positioning of homesteads relative to facilities such as markets and dips leads to the suggestion that development be done using small scale schemes. Because of the insight that Makatini stock owners have into co-operative management, and because of their awareness of the causes of overstocking problems, the author considers them best placed to deal with the area's impending overstocking problems and suggests they be supported in solving the problems by an active extension/education programme related to the overstocking question.

CHAPTER 5

THE ECONOMIC VALUE OF CATTLE ON THE MAKATINI FLATS

5.1 INTRODUCTION

Environmental management involves the manipulation of landscapes to improve their value to man; but the way in which a landscape's value is perceived varies depending on who the observer is (Linstone, 1981a; 1984). For example, a conservationist and a real estate developer may share the opinion that a particular landscape is valuable, but disagree on the reason for its value. Landscapes generally provide several existing or potential services (Zube & Simcox, 1987) and environmental or resource management is concerned with the identification and analysis of relationships between these services (Heeg & Breen, 1982; Bonnicksen & Becker, 1983; Bowonder, 1987; Johnson & Carothers, 1987). Economic evaluation of a landscape's resources, or the services it can provide, is an important part of environmental management because it allows the planner to draw up a "budget" of the landscape's values (Beaumont, 1985) which can be used to establish guidelines for, or to assess the impact of, development or management actions (Heeg & Breen, 1982).

Wetlands characteristically have a wide range of values (Etherington, 1983; Denny 1985; Mitsch & Gosselink, 1986) many of which are not directly marketable (Stearns, 1978; Faber, 1986). The importance of accurate evaluation of un-marketable natural resources is being increasingly recognised (Faber & Constanza, 1987; Zube & Simcox, 1987) and where this evaluation has not been integrated into management plans, losses of these landscape values have occurred (Attwell, 1970; Heeg *et al.*, 1986). As in other traditional African pastoral systems (Doran, 1979; Crotty, 1980; Colvin, 1983) cattle on the Makatini provide un-marketed utilities (CHAPTER 4) and it has been established in this study that pastoral management planning should be integrated with regional development planning (CHAPTERS 3 and 4). An understanding of the social significance of cattle and the perceptions of cattle owners (CHAPTERS 3 and 4) is essential but it cannot be used by regional planners as a basis for cost-benefit analysis of development or management input. The first objective of this Chapter then, is to provide an assessment of the economic value of all marketed and non-marketed utilities from cattle which can then be used to compare the value of cattle with that of other resources using a landscape value "budget".

The second objective is to assess the implications of the economic evaluation of all utility values for the identification of management options in African pastoral systems.

The objectives of government or institutional pastoral programmes in the Third World are commonly the improvement of regional "productivity" (Campbell, 1981; Awogbade, 1982; Yorama, 1983; Franke, 1984; Hundleby *et al.*, 1986). Productivity, defined in terms of benefits received (3.1) and on a regional scale, depends on what products are exported. Because of this, regional programmes tend to emphasise the importance of marketable utilities (Tapson & Rose, 1984). Evaluation of pastoral development programmes has shown that the failure to recognise non-marketed utilities, or the underestimation of their importance, are common causes of programme failure (Horowitz, 1979; Baker, 1980; Halderman, 1985; Colvin, 1985).

The third objective is to assess whether an economic evaluation of all utilities can be used to improve the external observer's understanding of the motivation behind local management practices, and thus improve his ability to make meaningful management proposals.

5.2 METHODS

5.2.1 Quantification of utility values

Cattle supply their owners with milk, draught power, meat, cash from sales and *lobolo* and are also an investment that can be used in times of financial catastrophe (Derman & Poultney, 1987; Tapson & Rose, 1984). The utilities that individual animals can provide depend on their age and sex and so herd composition must be taken into account when assessing the value of cattle herds (3.2 for methods of determination).

Data on the rates of disposal of cattle through markets and social exchange, and birth and death rates were obtained from KwaZulu Government dip tank record books (3.3.3 and Figure 3.3, p.34). Animal numbers were converted to animal units for each age/sex class using ratios suggested for Nguni cattle by Uys *et al.* (1985). Taking account of herd composition on the Makatini flats, ten head of cattle are the equivalent of 8.9 AU.

5.2.2 The asset value of cattle

The rate of return on an investment can be used as an index of the efficiency of an industry. To determine the rate of return on investment for the Makatini livestock system the value of returns from cattle and the capital invested in them had to be calculated. The capital invested in cattle was assessed using the following equation:

$$AV = \sum_{x=7}^{x=1} [P_x . V_x]$$

Where: AV = The asset value of cattle (Rand/AU)

P_x = Proportion of cattle in age/sex class x

V_x = Market value of cattle in age/sex class x (Rand/animal)

5.2.3 The market value of cattle

Prices of all the cattle sold at three local sales yards were recorded on 18 market days during one year (N = 1 584 animals). The age/sex class and origin (dip at which owners are registered) were recorded for each animal. Only 624 of the animals sold were from the study area and there was no significant difference ($p = < 0.005$) between their prices and those of other animals sold in any of the age/sex classes. The mean price of all cattle in each class was used as an estimate of market value. The market value of cattle was calculated using the following equation:

$$SV = \sum_{x=7}^{x=1} [P_s . P_{xs} . V_x]$$

Where: SV = The cash return to cattle owners from stock sales (Rand/AU/year)

P_s = The proportion of registered cattle sold each year

P_{xs} = The proportion of animals sold in age/sex class x

V_x = Market value of cattle in age/sex class x (Rand/animal)

5.2.4 The investment value of cattle

The market value of cattle is based on what owners remove, but this does not take account of increases in the size of herds through births, or increases in the value of cattle holdings as a result of inflation. These two factors contribute to the appreciation in the asset value of cattle (5.2.2) and can, therefore, be considered an investment. The investment value was quantified using the following equation:

$$IV = [[[1 + P_B - P_D - P_S - P_E - P_P] . A_{AM}] - 1] . AV$$

Where: IV = Investment value (R/AU/year)

P = Proportion of cattle holdings: B, which are born; D, which die; S, which are sold; E, which are used in social exchanges and P, which are bought in from outside the study area each year (see 3.3.3, p.33 and Table 3.2, p.36 for values)

A_{AM} = Annual appreciation in the mean market price of cattle (i.e. the mean market price one year as a proportion of the price the previous year, = 1.12; Figure 2.3, p.23)

AV = Asset value of cattle (Rand/AU)

5.2.5 The value of milk production

The total value of milk production depends on its value per unit volume and the quantity produced. Milk is used in the home and is rarely sold and since local stores do not stock fresh milk, no local market value for milk is available. Following the economic principle that supply influences value; cattle owners with large herds may feed milk to dogs and cats, while in other homesteads milk is apparently "more valuable" and consumption may be restricted to certain family members. These differences may even occur within a household on a seasonal basis, making assessment of the value of milk difficult. Derman and Poultney (1987) estimated goods in local stores to have a mark-up on prices in towns of 30 % . The standard supermarket price of milk during the study was R 1.10/litre (R 1.30/litre at Jozini and R 2.00/litre at Ndumu). R 1.40/litre is, therefore, a reasonable assessment of replacement costs of milk and has been used here as an estimate of its value to local people.

In this study it was not logistically possible to determine milk yields on the Makatini flats using random sampling of cows. Two cattle owners that were both willing and capable of recording milk yields from their cows were selected. Milk yields from all cows were recorded once a week. The author observed milking and recording of data once a month. Observations were made on 15 cows for 13 months, although only 10 cows completed a full lactation cycle in this period.

The value of production was determined using the following equation:

$$MPV = \frac{\sum_{x=10}^{x=1} [LP_x \, .DY_x] \, .P_6 \, .B \, .C_1 \, .C_2}{10}$$

Where: MPV = The value of milk production (Rand/AU/year)

LP_x = Lactation period during which milk was taken from cow x (Sample size N = 10 cows; mean = 245 days; s.d. = 30 days)

DY_x = Mean daily milk yield for cow x (mean = 3.64 litres/day/lactating cow; APPENDIX 2)

P_6 = The proportion of cattle in age/sex class 6 (= 0.48; Figure 3.4, p.36)

B = The calving interval (= 0.394 calves/cow/year; CHAPTER 3)

C_1 = A correction factor for loss of production due to mastitis (= 0.8; APPENDIX 1: 1.2)

C_2 = The replacement value of milk (1.4 Rand/litre)

5.2.6 The draught value of cattle

The value of cattle for draught power was calculated using the following equation:

$$DV = \frac{[P_3 + P_7] \cdot C_1 \cdot C_2 \cdot C_3}{4}$$

Where: DV = The draught value of the regional herd (Rand/AU/year)

P_3 = The proportion of animals in age/sex class 3 (= 0.056)

P_7 = The proportion of animals in age/sex class 7 (= 0.149)

C_1 = An estimate of the proportion of bulls and oxen that can be used for draught (= 0.62; 3.3.5, p.37; Figure 3.5B, p.38 and APPENDIX 1: 1.5)

C_2 = An estimate of the number of days/year draught teams work (= 200; APPENDIX 1: 1.7 and APPENDIX 3)

C_3 = The average daily hire rate for a draught team of four animals (= R 6.00; APPENDIX 1: 1.8 and R 5.00/team/day (Derman & Poultney, 1983))

5.2.7 The value of beef

Although cattle are not regularly slaughtered and cattle owners prefer to dispose of cattle in other ways (3.3.3 and APPENDIX 1: 1.4), beef consumption accounts for about 10 % of local people's meat intake (la Hausse de Lalouviere, P., 1984, in prep.).

Beef is not normally available in local stores but a few cattle are usually illegally slaughtered at livestock markets (KwaZulu stock inspectors pers. comm. and pers. obs., 1985 - 1987). If the cattle owner is able to sell all the meat from his slaughtered animal and is not heavily fined, his returns are greater than the sale value of the animal (pers. comm. cattle owners; 4.2, p.45 second interview method). It appears then, that the value of meat is higher or at least as high as the live animal's sale value. However, the old or sick animals which are usually slaughtered are not as valuable as the average animal sold at the market.

The condition of all the cattle sold at three local sales yards was recorded on 18 market days during one year (N = 1 584 animals) using the methods of MAFF (1978) and van Niekerk and Louw (1980). The mean market price of cattle in poor condition (condition score < 3.5 on a 0 - 10 scale) was determined. Uys *et al.* (1985) determined the proportion of cattle deaths from each of the age/sex classes in Maputaland cattle. The product of these proportions and the mean death rate for all cattle (CHAPTER 3) was calculated and used in the following equation to obtain an approximate value of meat from slaughtered or dead animals:

$$BV = \sum_{x=7}^{x=1} [P_x \,.\, P_D \,.\, V_x] \,.\, 0.6$$

Where: BV = Beef value (Rand/AU/year)

P_x = Proportion of cattle in class x

P_D = Proportion of cattle in class x that die or are slaughtered annually

V_x = The mean price of animals from class x which were sold in poor condition

0.6 = A correction factor to account for inedible meat, carcasses not recovered by owners and the difference between beef and cattle market value, a value based on the author's personal judgement after discussion with cattle owners (CHAPTER 4)

5.2.8 The social exchange value of cattle

It is not possible to put an accurate economic value to a "good quality" wife, or to family ties gained through a marriage contract which includes exchange of cattle. However, use of cattle in ceremonial or cultural activities represents a choice of this means of disposal rather than disposal through a market. The value of an animal used in social exchange must, therefore, be equal to or greater than its market value. The minimum value of cattle for social exchange was calculated using the following equation:

$$EV = \sum_{x=7}^{x=1} [P_x . V_x] . P_{\mathbf{x}}$$

Where: EV = The value of cattle for social exchange (Rand/AU/year)

P_x = Proportion of cattle in class x

V_x = Market value of cattle in class x (Rand/animal)

$P_{\mathbf{x}}$ = The proportion of cattle disposed of annually through social exchanges = 0.146

5.2.9 <u>The total value of cattle</u>

The total value of cattle to their owners on the Makatini flats was calculated as the sum of all utility values described above (5.2.3 - 5.2.8).

5.3 RESULTS

Many of the values used in the above equations (5.2.2 - 5.2.9) were obtained from analyses which have been discussed in other Chapters of this thesis. Where this has occurred values have been presented, with reference to their origin, after the term definitions for each equation and are not repeated here. Raw data on the proportion of animals sold from each age/sex class, the mean market value for each class and the proportions of cattle in each class that die annually, which were used in the equations are given in APPENDIX 4 .

The asset value of cattle was calculated to be R 277/AU, which means that in 1986 the total value of cattle in the study area was an estimated R 4 686 900 . The estimated values of the utilities cattle provide on the Makatini flats are given in Table 5.1 . Cattle provide an excellent return on investment and the owner will receive a total annual return from utilities greater than the total value of his cattle holdings/assets (Table 5.1).

Milk is the most valuable utility, providing returns estimated to be worth more than four times that of any other utility (Table 5.1). The estimated annual return from milk is 61 % of the total asset value of cattle.

Table 5.1 The estimated value of utilities from cattle obtained by stock owners on the Makatini flats in 1985/1986.

UTILITY	VALUE			
UNITS	Percentage of total value of utilities	Rand/AU /year	Rand/Rand of assets /year	Rand/year: Total for study area
Milk production	62.2	168.71	0.608	2 848 000
Social exchanges	15.3	41.24	0.149	698 000
Draught power	12.5	33.91	0.123	574 000
Meat	4.2	11.43	0.041	194 000
Sales	3.6	9.69	0.035	163 000
Investment	2.2	5.82	0.021	99 000
Total	100	270.26	0.977	4 576 000

Of all utility value estimates made, cattle sale is the only marketed utility and, at present, it is also the least valuable tangible utility (Table 5.1). Under present management practices cattle sales are worth only approximately one third of the returns from draught. Although the market value of cattle is appreciating at 12 %/year, the investment value of cattle is low (Table 5.1) because stock owners dispose of a high proportion of their cattle (CHAPTER 3). Non-marketed utilities make up approximately 94 % of all returns to local cattle owners.

5.4 DISCUSSION

5.4.1 The method of utility evaluation

Before discussing the significance of estimated values, some comment on the accuracy of the estimates and the interpretation of the values is necessary.

Assessment of the economic value of non-marketed utilities is theoretical and usually involves assumptions, which means that normal statistical analysis of the estimate's accuracy may be meaningless. Statistics can be applied to the data used in determination of the estimate but confidence in the accuracy of the estimate depends on the confidence that can be placed in the method, including its assumptions, as a means of assessment.

Since no assumptions were made in assessment of the asset, market and investment values of cattle; these assessments can be considered objective.

In this study a replacement value for the milk produced (R 1.40/litre) was assumed as a reasonable estimate of its true value. In other areas of KwaZulu milk has been traded locally for R 0.30/litre, approximately one third of the town store prices at the time (Gandar & Bromberger, 1984). On the basis of this it could be argued that the milk value estimate made here is between three and five times too high. However, as the purpose of this analysis is to compare the values of different resources, a replacement value assessment is considered appropriate.

The value of cattle for social exchange was based on the assumption that the owner has chosen to exchange cattle rather than to sell at a market and that the exchange value must, therefore, be higher than the market value. Market value was used in the equation to estimate the total exchange value and the value given for exchanges should be considered the minimum return that cattle provide from this utility.

Assessment of draught value was based on the prices charged for the hire of teams. However, draught teams are not hired out during the optimum ploughing season (APPENDIX 1: 1.8) and rates paid are for ploughing services rendered toward the end of the season. This means that the use of hire charges in the estimation of draught value probably results in an underestimation of the true value of draught teams to their owners.

Estimation of the beef value involves assumptions about both the value per carcass and the quantity of carcasses. The correction factor for the quantity of recoverable meat is a deliberate underestimate, and the means of assessing the value per carcass can also be considered an underestimate if the same arguments as used in discussing exchange value assessment are used.

All the non-marketed utility values are to some extent contrived but, with the possible exception of the milk value, those given here are probably all underestimates.

5.4.2 Cattle utility value and regional development planning

From a regional planning perspective livestock and pastoral resources are only one component of the local economic system (Urban *et al.*, 1987) and the significance of the results obtained needs to be assessed in this context. Heeg and Breen (1982) estimated returns of R 200/ha/year from the proposed Makatini irrigated agriculture development, of R 517 000 - R 618 000/year for fish catches and of R 200 000 - R 400 000/year gross income from a proposed conservation / tourism development on the Pongolo floodplain. Even if these estimates are doubled to take account of an inflation rate of between 10 and 20 % in the six years between Heeg and Breen's study and this one, the estimated total utility value of cattle (R 4 576 000/year) is four to five times the estimated value of the fisheries or the proposed tourist development. Returns from cattle per hectare of pasture (R 73/ha/year) are only about one fifth of the projected profits from irrigated agriculture, but it should be borne in mind that this analysis does not take account of possible preferences for grazing on areas such as the floodplain. Before meaningful comparisons between cattle utility value and the value of other resources can be made on the basis of land area some assessment of grazing resource distribution and use is needed (CHAPTER 6).

On the Makatini flats only 3.6 % of cattle utility value is realised through cattle markets and even if all obvious utilities; milk production, draught power and cattle sales, are included in utility evaluation, 21.7 % of the total utility value is not accounted for. This shows that the economic implications of pastoral resource degradation or substitution of pastures with other forms of land use cannot be understood without including a consideration of all utility values.

The above discussion illustrates that although only some people have access to utilities provided by cattle on the Makatini flats (22 %, CHAPTER 2; 7.5 - 57 %, Derman & Poultney, in press) and cattle do not provide large cash returns, cattle are still important to the area's economy and thus to regional planning. In the past the importance of cattle has not been appreciated, despite the fact that an impact assessment and development proposals were made for the study area after the construction of the Pongolapoort dam (Heeg & Breen, 1982) and also that the Pongolo is considered one of the best researched floodplain ecosystems in Africa (Walmsley, in press). This leads to the suggestion that it is important to include an assessment of the value of livestock in African regions where stock are kept in a subsistence economy, even if they are not obviously of economic importance, and that assessment of non-marketed utility values is particularly important in planning regional resource management for these areas. Most important is that the economic evaluation allows the regional planner to assess the importance of traditional stock farmers' needs and practices in economic terms and it is possible, therefore, to include them in the resource value "budgeting" process.

5.4.3 Utility value and identification of management options

With the quantification of the value of specific utilities the desirability and feasibility of management practices that might increase their value can be assessed. There are many possibilities of how the economic evaluation might be used in management. A single example, that of draught power, is given here.

In evaluation of draught power the potential value of services supplied by all bulls and oxen was multiplied by a correction factor (0.62) to account for the fact that 62 % of cattle owners have too few cattle to span a team (CHAPTER 3). If herd size were increased, or if some cattle owners were persuaded to co-operate in the use of draught cattle, the correction factor would be closer to one. An increase to 0.8 would be worth an estimated R 166 700/year. This means that a programme that costs < R 150 000/year and which brings about a change in the factor from 0.62 to 0.8 would be cost effective (Haplin, 1987). This example shows that an economic evaluation of utility values is a useful tool for the identification of feasible government or institutional projects to increase the utility value of stock in a traditional system.

The importance of milk as a utility and the relative insignificance of returns from cattle sales leads to the suggestion that cattle on the Makatini should be considered dairy cattle and system management planned accordingly. The important question arising from this is; whether milk yields on the Makatini are unusually high for African systems or if the dominance of milk and other non-marketed utility values over the sale of stock is uncommon. If not, government or institutional planning for African pastoral systems should be directed at improving milk rather than beef production.

Milk yields on the Makatini are slightly higher than those for other African systems but are similar to those reported in other KwaZulu studies. The seasonal range in production was 2.5 - 4.3 litres/day/lactating cow, compared with 0.38 - 3.23 litres/day/lactating cow reported for a traditional Tanzanian system (Sullivan *et al.*, 1980). The mean daily output of 2.44 litres/cow is above Blair-Rains and Kassam's (1980) estimate of the mean output for African cattle, 2.0 litres/cow/day and that reported for the Transkei by Bembridge (1984) and considered normal for African countries (1.72 litres/cow/day).

Stobbs (1967) reported milk yields of 580 - 666 litres/cow/birth in East Africa, whilst on the Makatini mean yields of 858 litres/cow/birth were obtained.

In KwaZulu, Gandar and Bromberger (1984) recorded an output of 2.3 litres/day/cow in the Mahlabatini district and, under test conditions at the Barlow Combine, calf weight gains indicated a total production of 5.51 litres/cow/day (unpublished data, Department of Development Aid, 1987). In their investigation of the reasons for low market offtake in the KwaZulu traditional stocking system, Tapson and Rose (1984) also conclude that cattle should be considered to be dairy rather than beef animals.

It is widely recognised that the role of cattle marketing in Africa is usually secondary to other utilities (Doran *et al.*, 1979; Crotty, 1980; Anthony *et al.*, 1979; Colvin, 1983). Danckwerts (1974) estimated the contribution of stock to subsistence utilities in a mixed cropping/livestock economy in Zimbabwe to be worth four times that of cattle sales. Behnke (1982) found that in Botswana the proportion of returns contributed by non-cash utilities (including death and home slaughter) decreased with increasing herd size, but always exceeded cash returns. In the light of this review, the dominance of non-marketed utilities evident on the Makatini does not appear to be unusual. As in other African pastoral systems, the sale of slaughter cattle can only be regarded a secondary industry (Baker, 1979; Jacobs, 1980; Colvin, 1985) and consequently, programmes directed at increasing cattle utility value should concentrate on increasing the output of non-marketed utilities (U.S.A Institute for Development Anthropology, 1979) with improved milk production being particularly important (de Glas & Venema, 1982; Yorama, 1983; Homewood & Rodgers, 1984).

5.4.4 Utility value and the rationale behind local stocking policy

In view of the high rate of return on investment received by Makatini cattle owners (98 %/year), it is easy to understand the philosophy that "cattle is wealth" (Jerve, 1981). A cattle owner is wealthy as a result of the utilities he receives and the extent of his wealth is understood by people in the same socio-economic system. It is only to an outsider, who considers only marketed utilities, that the reasons for not selling more cattle are unclear.

Investment in livestock on the Makatini makes good economic sense and the local desire to increase personal herd size (APPENDIX 1: 1.10) is understandable.

It is important to note that management practices of Makatini cattle owners (low market offtake) can be explained on economic grounds without considering the importance of social customs. The results show that a cow produces milk each year with a replacement value above its own market price and that a working draught animal provides an annual return value higher than its market price.

It was stated in CHAPTER 3 that low offtake can be explained because cattle are disposed of within the system as *lobolo* rather than at markets. It is suggested here that cattle are important in social transactions because they are a valuable asset in the local economy. If cattle were worth only what they can be sold for, cash would probably be more readily accepted as payment of *lobolo*, as was found by Tapson and Rose (1984) in KwaZulu sugar cane growing areas. However, on the Makatini an exchange of cattle is an exchange of "working assets" (Wantanabe & Mueller, 1984) from which good returns of both non-marketed utilities and capital can be generated.

From this it is suggested that overstocking in traditional systems is more an economic than a social problem. It occurs because in a subsistence / traditional system cattle can provide utilities with high values relative to their own asset value, even when in poor condition. The importance of basing management decisions on local traditions and perceptions of the cattle owners is well documented (Mwaniki, 1980; Nankumba, 1982; de Glas & Venema, 1982; Marchot, 1983) but what is not commonly realised is that management on this basis is necessary, because traditions and perceptions are based on economic principles applied to local conditions. Most important then, is to establish what utilities are provided by cattle and the value of these in the local context. As long as the utility value is high relative to the asset value people can be expected to invest in more cattle or to allow cattle numbers to increase.

Although the benefits from cattle ownership are, at present, extremely high on the Makatini flats, this does not mean that "overstocking" (CHAPTER 4) does not occur or that the "tragedy of the commons" (Hardin, 1968) does not apply. It is clearly against the best long-term interests of cattle owners to allow cattle numbers to increase, but at the same time cattle owners cannot maximise their short-term gains if they sell a high proportion of their cattle. In an assessment of the management of a pastoral system in Sudan, Frankenberger (1986) states that local cattle owners tend to emphasise short-term interests and he considers broad-based institutional involvement necessary to ensure that resource degradation, particularly that caused by overstocking, does not occur in the long-term.

The results of this survey support Frankenberger's statement, but whether a system be managed for short- or long-term gain is more a moral than a scientific question. It is generally accepted that subsistence farmers and traditional pastoralists are among the world's poorest people (Blair-Rains & Kassam, 1980; Wantanabe & Mueller, 1984; Beukes, 1987; Derman & Poultney, 1987) and it is reasonable to assume that the more marginal a person's existence the greater will be his tendency to maximise short-term gain at the expense of long-term security. The question of whether government or institutional involvement should be directed at ensuring "protection" of the cattle owner's long-term interests could be rephrased as: whether it is acceptable to increase a poor man's poverty now in order to save him from worse poverty later. It is suggested here that the role of institutional or government programmes should be to ensure that cattle owners are aware of the fact that they are acting against their own best long-term interests and to assist them in implementing the changes that they consider appropriate. This does not mean that pastoralists will manage grazing resource in a manner that the planner considers "prudent" (Fowler, 1981), but that the resource will be managed according to what a well-informed cattle owner considers to be in his best interests.

5.5 CONCLUSIONS

The values of utilities, as defined in this Chapter, provide a basis for the comparison of pastoralism with other forms of land use on the Makatini. Before resource values can be compared on the basis of land area, an assessment of the distribution and use of pastures needs to be made.

Identification of specific management objectives is facilitated by the economic evaluation of each utility, and the estimation of the economic feasibility of proposed projects for utility value enhancement is made possible. Non-marketed utilities, in particular milk production, provide most of the returns from cattle and emphasis should be placed on improving returns from these utilities, rather than from cattle marketing both on the Makatini and in traditional African pastoral systems generally.

Despite the apparent "low productivity" of the system by Western standards (Fowler, 1981; McDowell, 1985; CHAPTER 4), the livestock industry is highly valuable and cattle ownership is a good form of investment for local people. The high value of non-marketed resources relative to market prices provides an insight into why herd offtake is low. Institutional involvement in management may be necessary in order to prevent overstocking and a reduction in utility values in the long-term, and it is suggested that this should be achieved through an extension programme.

CHAPTER 6

THE USE AND VALUE OF VEGETATION ON THE PONGOLO FLOODPLAIN

6.1 INTRODUCTION

Seasonality in rainfall over much of Africa results in an annual stress period which affects both livestock and pastoralists (Sullivan *et al.*, 1980; Hill, 1985). Consequently, pastoral management strategies which ensure the availability of forage throughout the year must be sought and the most important of these is probably nomadism or seasonal transhumerant herding (Galaty & Salzman, 1981; Basset, 1986; Grandin & Lembuya, 1987; Oba & Lusigi, 1987). Wetlands, particularly floodplains, play an important role in the provision of high quality forage during the dry season when other grazing is scarce and it is toward these areas that migrations are commonly directed (Scudder, 1980; Cambrezy, 1981; De Groot & Marchand, 1982; Drijver & Marchand, 1986). Rainfall on the Makatini is light and seasonal (CHAPTER 1) and so an annual "stress period" would be expected, but the cattle owners are not nomadic. The question which arises is; how do the patterns of vegetation use on the Pongolo floodplain differ from those on other major African floodplains ?

The importance of understanding traditional strategies of pastoral resource use for the successful planning of pastoral system management is well documented (Perrier & Craig, 1983; Deng, 1984; Hussein, 1984; Jacobs, 1986; Hogg, 1987). However, most descriptions of patterns of pasture use on African floodplains are entirely subjective and few attempts have been made at formal quantification (Rees, 1978c; Rogers, 1980; Bryant, 1982; Gillen *et al.*, 1985). If traditional methods of pasture use are to be incorporated into development planning, there is a need for an understanding of the motivation behind herding practices (CHAPTER 4) and for quantification of the patterns of vegetation use. In this Chapter an attempt is made to quantify the importance of floodplain vegetation to the Makatini pastoral system and to establish what determines the patterns of vegetation use.

Modification of the hydrology of floodplains important to pastoralists has occurred in many African systems as a result of dam construction (Fielder, 1973; Imevbore & Bakare, 1974; Drijver & Marchand, 1986; Breen & Heeg, in prep.). Large-scale irrigation development in Africa is clearly a potential threat to pastoral systems because the development may cause reductions in the land area available to stock or may change river hydrology causing disruption of traditional patterns of pasture use (Kloos, 1982; Marty, 1983). If pastoral systems are to be managed effectively within the context of such development programmes it is clear that the importance of different pasture areas must be known. Further, for pastoralism to be included in a general resource development plan, the understanding of patterns of use must be expressed in economic terms i.e. the value of pastoral resources per unit area (CHAPTER 5). The final issue discussed in this Chapter is the consequences of the patterns of vegetation use on the Pongolo floodplain for the management of the Makatini pastoral system, the planning of regional development on the Makatini and for planning the management of pastoral systems which are dependent on other African floodplains.

6.2 METHODS

6.2.1 Quantifying the use of vegetation

Plant communities on the floodplain were described and mapped by Furness (1981; CHAPTER 1). Using ground surveys and aerial photographs taken during this study, Furness's maps were updated. His descriptions of plant communities were used as a basis for distinguishing between the different vegetation types that cattle use. Plant communities dominated by tree species were categorised as browse and all off-floodplain communities were considered a single vegetation type. Furness's *E. pyramidalis / C. fastigiatus* community was considered to be two separate vegetation types the distinction being made on the basis of which of the two species was dominant in a stand during the 1985/1986 study. The area of each vegetation type in each pastoral zone (Figure 2.2, p.21) was determined from the updated maps using planimetry (APPENDIX 5).

Manpower limitations prevented regular visitation of all 7 500 ha of floodplain potentially available to cattle so monthly, day-long, surveys of the numbers and distribution of cattle were made on a 1 500 ha area (Figure 2.2, p.21; zones 2 and 3). This area was selected because it included areas of each plant community in approximately the same proportions as the floodplain as a whole (APPENDIX 5), and because the author considered the physical structure of this area of the floodplain to be representative. To account for any cattle movement during the day, the selected area was surveyed twice on the same day; in the morning, the period when most grazing takes place, and again in the afternoon.

The reliability of the technique was tested using two methods. Firstly, two independent observers surveyed the area on the same day. This test produced differences of < 2 % in the numbers of cattle seen (N = 3 days). Secondly, the area was surveyed on two consecutive days (N = 5 days). This test showed differences of < 4 % . As some day to day differences in stocking densities would be expected because of the seasonal trends in pasture use, this difference is probably not all sampling error and it seems reasonable to assume that at least 96 % of all cattle using the surveyed area were accounted for.

Two herds of cattle, one from a homestead 0.1 km from the floodplain edge and one from 2.3 km away, were observed for all the daylight hours of one day each month to establish an "activity budget", or account, of how they spend their time. Nearly all homesteads in the study area are located less than 2.5 km from the floodplain's edge.

The mean stocking density of each floodplain vegetation type in the surveyed area was calculated monthly using the following equation:

$$SD_1 = \frac{N_{A1}}{A_1} \cdot \frac{T_A}{[T_A + T_P]} + \frac{N_{P1}}{A_1} \cdot \frac{T_P}{[T_A + T_P]} \cdot C \qquad \text{........(1)}$$

Where:

SD_1 = Stocking density in vegetation type 1 (animal units/ha = AU/ha)
N_{A1} = Number of animals on vegetation type 1 in the morning
A_1 = Area of vegetation type 1
T_A = Duration of morning grazing period (from activity budget)
T_P = Duration of afternoon grazing period
N_{P1} = Number of animals on vegetation type 1 in the afternoon
C = 0.89 a conversion factor for animal numbers to animal units (AU), (methods in CHAPTER 3)

stocking densities in the forests surrounding the floodplain were calculated using the following equation:

$$SD_O = \frac{N_T - [\sum_{n}^{1} SD + [P \cdot N_T]]}{A_O \cdot C} \qquad \text{........(2)}$$

Where:

SD_O = Stocking density off the floodplain (AU/ha)

N_T = Number of cattle in the zone (Figure 2.2, p.21)

n = Number of floodplain vegetation types

P = The proportion of cattle < six months old (weaned)

A_O = Area of off-floodplain vegetation available for grazing

C = 0.89 a conversion factor (animal numbers to AU)

Despite the lack of fencing cattle rarely move outside communally grazed tribal zones (Figure 2.2, p.21; CHAPTER 3). Because of differences in both stock densities and the relative proportions of each pasture type within each area (Table 3.1, p.36), use in un-surveyed zones was calculated using the following equations:

$$X_1 = \left(\frac{N_1 \cdot A_2}{N_2 \cdot A_1}\right) + \left(\frac{N_1 \cdot A_3}{N_3 \cdot A_1}\right) + \;\ldots\ldots\; \left(\frac{N_1 \cdot A_N}{N_N \cdot A_1}\right) \qquad \text{........(3)}$$

Where:

X_1 = A factor used in equation 4

N_1 = Numbers of cattle, (AU) using vegetation type 1 (SD_1 times A_1 from equation 1)

A = Area of a vegetation type

N = Number of available vegetation types including off-floodplain vegetation

In each pair of brackets in equation 3 the ratio; animal numbers using vegetation type 1 : numbers of animals using another vegetation type (2 - n) is divided by the ratio area of vegetation type 1 : area of another vegetation type (2 - n). The solution for each bracket is the stocking density in vegetation type 1 relative to that in the other vegetation type. X is the sum of these relative stocking densities, has no units and was calculated only as a component of equation 4 below.

$$RD_1 = \frac{X_1}{\sum_{x=n}^{x=1} X} \qquad \ldots\ldots\ldots\ldots(4)$$

Where:

RD_1 = Relative stocking density of vegetation type 1 (values are dimensionless; the sum of relative stocking densities for all vegetation types = 1)

X = X from equation 3

Equation 4 was used to calculate relative stocking densities for each vegetation type in surveyed zones. The values obtained were used in equation 5 to estimate numbers of animal units using each vegetation type in each of the un-surveyed zones.

$$N_{1x} = \frac{RD_1 . A_{1x} . N_{Tx}}{\sum_{nx}^{1} [RD . A]} \qquad \ldots\ldots\ldots(5)$$

Where:

N_{1x} = The number of cattle using vegetation type 1 in un-sampled zone x

RD = RD from equation 4

A_{1x} = Area of vegetation type 1 in un-sampled zone x

N_{Tx} = Number of cattle registered at dip tank in zone x

nx = Number of vegetation types in zone x

Because water levels regulate floodplain accessibility, the area of each vegetation type used in equation 1 was recalculated each month. Accessibility depends on floodplain morphology, on the height to which floods rise and on the time since a flood event has occurred (Figure 6.1). During large floods (river flow peak > 200 cumecs) all floodplain vegetation is inundated (Heeg & Breen, 1982; Alexander & Roberts, in press). Smaller floods (river flow peak 80 - 200 cumecs) fill floodplain pans but water stays within the river, the flow channels through the levees, or in the pans. Once pans lose contact with the river they gradually dry out. Areas of land not exposed ten months after a flood event are rarely exposed and usually have no grazeable vegetation.

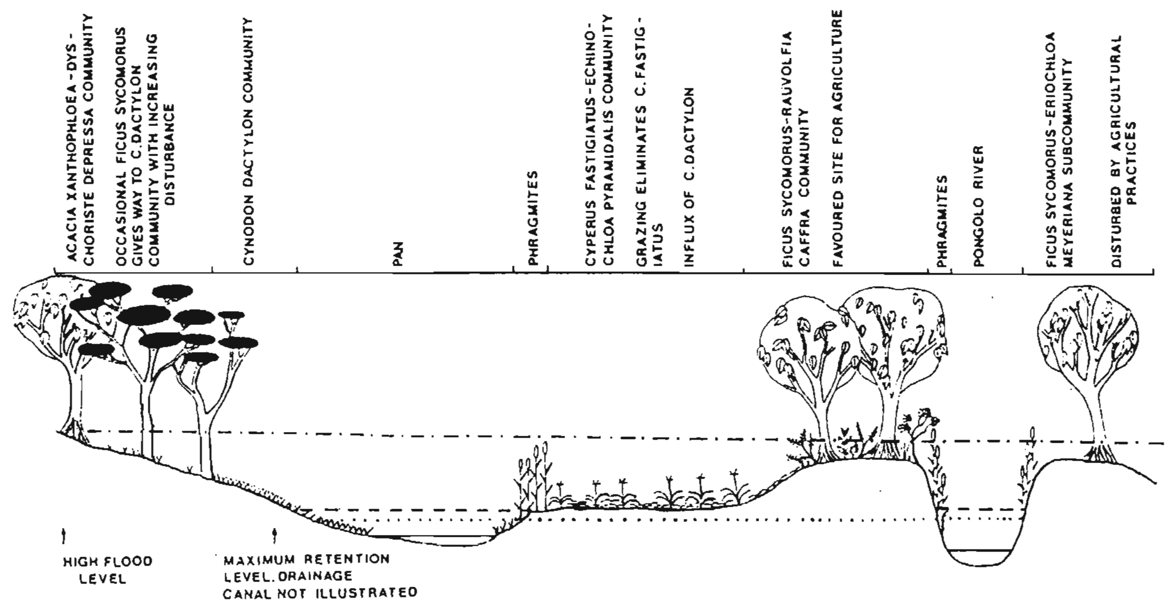

Figure 6.1 Diagrammatic section across the Pongolo floodplain showing the distribution of different plant communities and approximate water levels; during a flood of river flow 400 cumecs, – · –; during a flood of river flow 80 cumecs, – – –, and after 10 months of river flow below 20 cumecs ——. ···· = The level at which pans lose contact with the river (Maximum retention level). (Modified from Heeg & Breen, 1982).

Table 6.1 Equations for floodplain vegetation area calculation. F = month of large flood. f = month of small flood. Time = time since last large or small flood. C = vegetation type *Cynodon dactylon* which is exposed before other vegetation because of its locality on the floodplain edge (Figure 6.1). X1 = area vegetation type 1 immediately after flood recession. Y1 = area vegetation type 1 ten months after floods.

TIME (Months)	EQUATION
F	A = 0
FC	A = 0.5 . X
f	A = X1
1	A = 0.9.X1 + 0.1.Y1
2	A = 0.8.X1 + 0.2.Y1
3	A = 0.7.X1 + 0.3.Y1
4	A = 0.6.X1 + 0.4.Y1
5	A = 0.5.X1 + 0.5.Y1
6	A = 0.4.X1 + 0.6.Y1
7	A = 0.3.X1 + 0.7.Y1
8	A = 0.2.X1 + 0.8.Y1
9	A = 0.1.X1 + 0.9.Y1
10	A = Y1

One month after a flood with a river flow peak of 400 cumecs pans were mapped using aerial photography. The area was then remapped after ten months of low river flow and using land surveys (APPENDIX 5). Areas for equation 1 were calculated monthly for each zone on the floodplain using the equations in Table 6.1, p.73. Cattle numbers and stocking density were calculated monthly for each vegetation type available in each of the twelve different zones.

6.2.2 Determination of the importance of floodplain grazing

The importance of floodplain grazing was determined using four methods of assessment:

a) Comparison of the stocking density of floodplain vegetation with that of off-floodplain areas.

b) Comparison of the total time spent grazing in each vegetation type.

c) Estimation of the total economic value of each vegetation type.

d) Comparison of the condition of cattle with access to floodplain vegetation with that of animals without access to the floodplain.

Comparisons of cattle condition (d) were made to assess the importance of floodplain vegetation in maintaining cattle condition through the dry winter period.

The methods for determining cattle densities and animal numbers using each vegetation type have been described above (6.2.1). Economic value was calculated as the product of the mean stocking density, the areas of land covered by a vegetation type and the total annual return from cattle (Rand/AU/year, CHAPTER 4).

Cattle condition was assessed in late September 1986 at the end of the dry season after a year with low rainfall (CHAPTER 3), when cattle condition would be expected to be low. The visual assessment methods of MAFF (1978) and van Niekerk and Louw (1980) were used. Cattle from five different areas in the northern Maputaland region were assessed (Figure 1.6, p.13). All animals seen during walks along stratified transects through each area were assessed.

Two of the assessed areas have some floodplain vegetation but in one area off-floodplain vegetation is sand forest (CHAPTER 1) and in the other it is mixed bushveld (CHAPTER 1). The mixed bushveld area with no wetlands was included for comparison because its vegetation is similar to that surrounding the floodplain, its rainfall is similar (Schulze, 1982) and it has a similar stocking density (unpublished KwaZulu dipping records, 1986). The Lebombo bushveld was included because it has a similar vegetation and stocking density, but receives a much higher rainfall than the Makatini (Schulze,1982). The Palmveld/Mozi vegetation consists of a mosaic of wetlands and sweetveld grasses (Moll, 1980). The area has a high rainfall relative to the Makatini flats and a stocking density of less than half that in the study area. Palmveld was included in the comparison because cattle are kept under a similar stocking system to that in the study area, but would not be expected to lose condition in winter.

6.3 RESULTS

6.3.1 <u>The importance and value of floodplain grazing</u>

There was an average of 19 024 cattle (16 934 AU) in the study area during the 1985/1986 study period. Mean stocking densities on the floodplain and in surrounding dry-land areas were 0.78 AU/ha and 0.24 AU/ha respectively so, while floodplain vegetation covers only 8 % of the total vegetation area available to stock, cattle spend an estimated 23 % of their grazing time on it. The floodplain is a favoured grazing area and has a higher value per hectare than dry-land areas (R 219/ha/year and R 63/ha/year respectively) but its total value (R 1 053 000/year) is lower than that of the larger surrounding forest areas (R 3 585 000/year).

Cynodon dactylon and *E. pyramidalis* both have an extremely high mean stocking density relative to that of other Makatini vegetation types and, therefore, have a much higher value per hectare (Table 6.2). *Cyperus fastigiatus* and *Phragmites* communities also have a high stocking density relative to that in floodplain forests and fields (Table 6.2) but because they have a relatively

Table 6.2 The area, stocking density and value of vegetation on the Makatini flats. Relative stocking densities indicate the predicted percentage of grazing time that would be spent on each vegetation type if each vegetation had the same available area i.e. it shows the degree of preference for each vegetation type. Economic values are for all utilities received by local cattle owners (CHAPTER 5).

PLANT COMMUNITY	RELATIVE STOCKING DENSITY %	AREA ha	STOCKING DENSITY AU/ha	VALUE Rand/ ha/year	TOTAL VALUE Rand/ year
Cynodon dactylon	34	443	2.35	635	279 000
Echinochloa pyramidalis	31	827	2.17	586	481 000
Cyperus fastigiatus	15	208	1.09	295	61 000
Phragmites	11	173	0.77	208	36 000
Floodplain fields	3	2 675	0.18	49	129 000
Floodplain forest/browse	1	149	0.05	14	2 000
Floodplain sand flats	1	326	0.04	11	3 000
Off-floodplain forests	4	56 300	0.24	64	3 585 000
Total/All areas	100	61 100	0.28	77	4 576 000

small area compared to floodplain fields, they have a lower total value (Table 6.2). The mean stocking density of floodplain fields is higher than that in floodplain forests, but is slightly lower than that in the dry-land areas surrounding the floodplain (Table 6.2).

The similarity in cattle condition in all five areas surveyed (Figure 6.2) has two important implications. Firstly, the condition of cattle which graze mixed bushveld and have no access to wetlands was no lower than that of animals in the study area. Access to the floodplain does not, therefore, appear to be necessary for the maintenance of animal condition during the winter of years of normal rainfall and at the stocking densities that occurred during the study period. This conclusion only applies to the parts of the study area where dry-land areas have mixed bushveld vegetation.

Secondly, the results show that cattle throughout the study area remain in a condition equivalent to that found in areas with a relatively high rainfall, even during drought periods. This is corroborative evidence supporting the thesis that the floodplain does contribute to the maintenance of cattle condition in winter or during severe droughts. However, because of the generally good condition of cattle during the study, the result for areas containing sand forest and floodplain vegetation remains inconclusive. For these areas, more important than the comparative analysis is the fact that cattle condition remained generally good during the winter when local owners found it necessary to move animals onto the floodplain (6.3.2).

6.3.2 The patterns of use of floodplain vegetation

The amount of time animals spend grazing on the floodplain increases during the dry season (Figure 1.4, p.9) reaching a peak in September just before the rains (Figure 6.3A) In September 1985 approximately half of all grazing time was spent on the floodplain (Figure 6.3A).

In addition to increased floodplain use in winter, stocking densities on accessible floodplain areas peaked when water levels in the pans were raised by a small flood (river flow 60 cumecs), (Figure 6.4A). The stocking density of the floodplain as a whole did not increase at that time (Figure 6.4B) and, therefore, it appears that high stocking densities in February 1986 were the

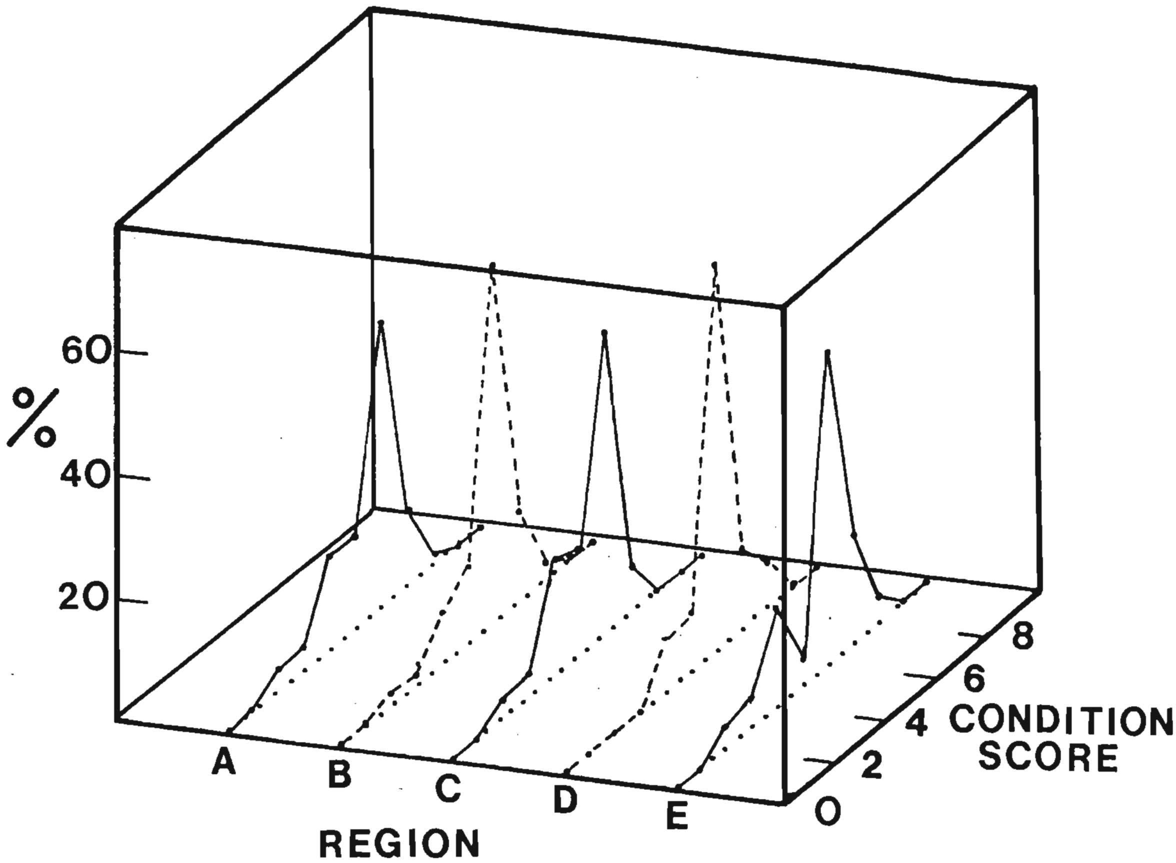

Figure 6.2 The condition of cattle in five different regions of northern Maputaland. The vegetation type refers to the type of forage available to stock in each region. A = Floodplain and sand forest pastures (N = 705 animals). B = Floodplain and mixed bushveld pastures (N = 549). C = Lebombo mountain mixed bushveld (N = 408). D = Mixed bushveld (N = 82). E = Palmveld (N = 562), (Figure 1.6, p.13). For condition scores, 10 = grossly fat animals, 0 = on the point of death from starvation, 5 - 6 is an average condition, trim animal (MAFF, 1978). The Y axis shows the percentage of animals assigned each condition value.

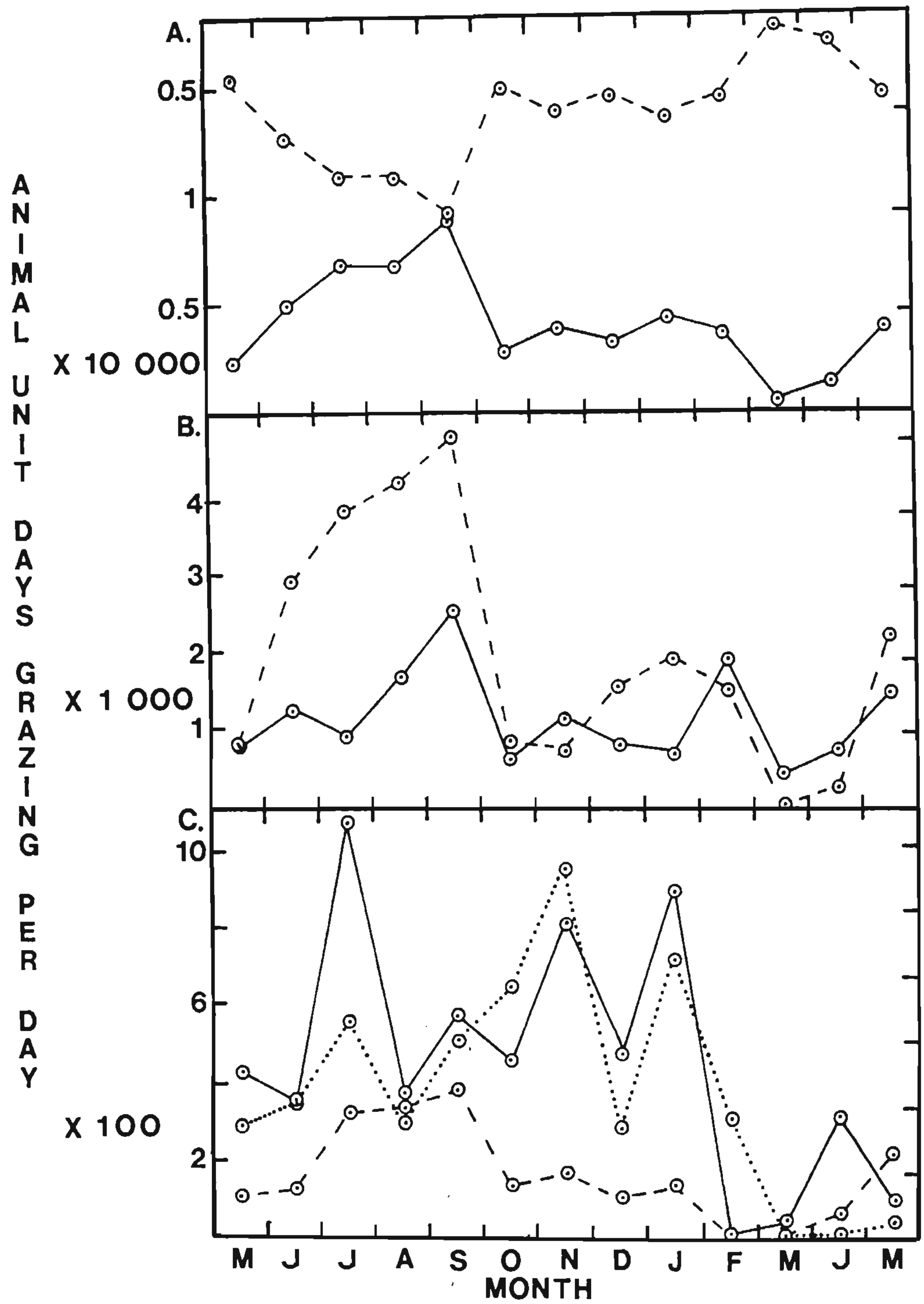

Figure 6.3 The use of vegetation on the Makatini flats as grazing. Units are the total number of animal unit grazing days/day spent on each pasture. A: floodplain vegetation, —— and on off-floodplain vegetation, - - -. B: *Echinochloa pyramidalis*, - - -, *Cynodon dactylon*, ——. C: Agriculturally disturbed areas and fields on the floodplain, ····. *Phragmites* spp., - - - and *Cyperus fastigiatus* ——.

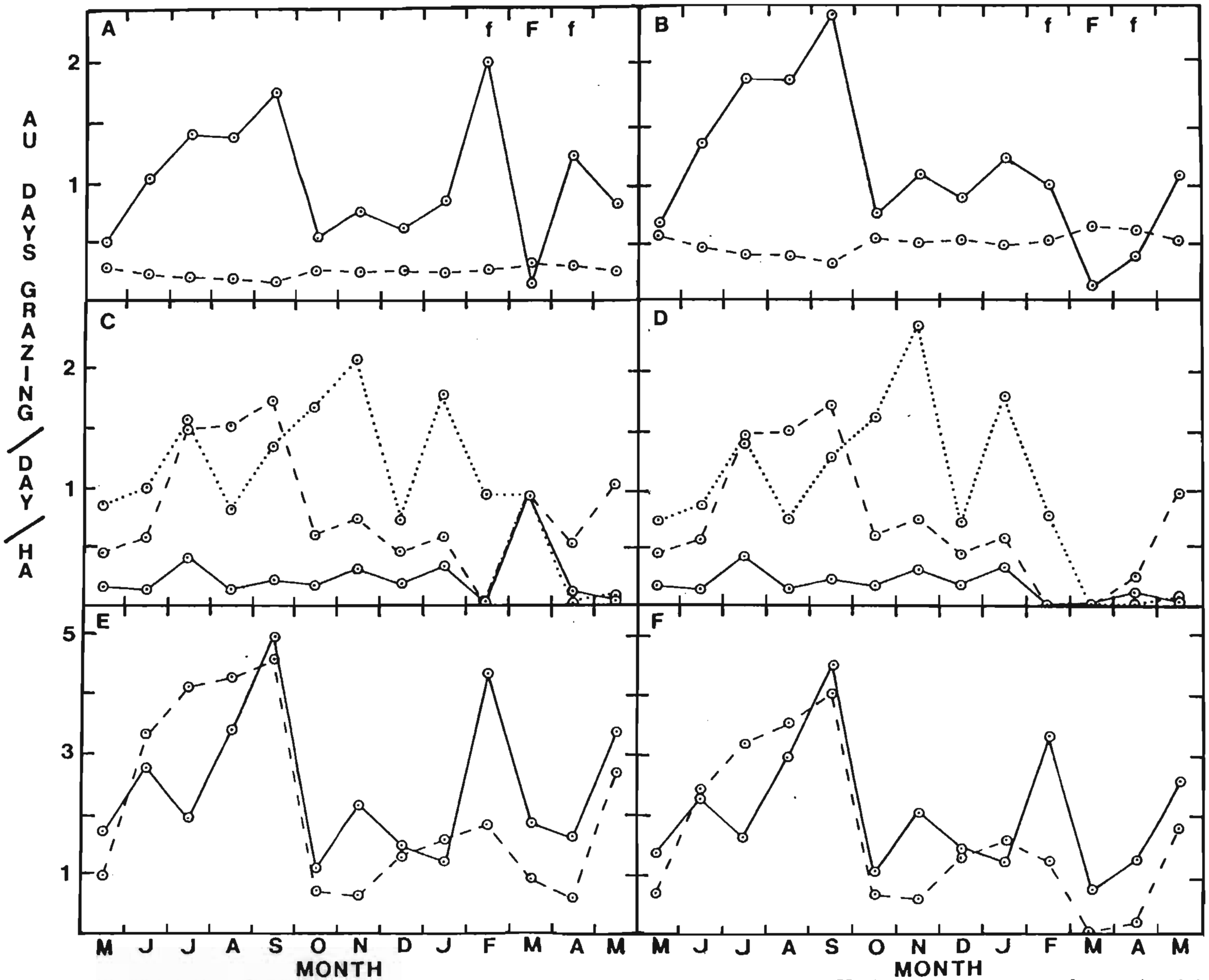

Figure 6.4 The stocking density on vegetation types of the Makatini flats. A, C & E show stocking densities calculated for accessible pastures only. B, D, and F show stocking densities calculated from the total cumecs. area of each pasture. f = Months when river flow was 50 - 100 cumecs. F = Months of river flow > 100 A & B, - - - = All floodplain pastures, —— = Off-floodplain pastures. C & D, —— = Floodplain areas disturbed by agriculture; - - -, = *Phragmites* spp. and · · · · = *C. fastigiatus*. E & F, —— = *C. dactylon* and - - - = *E. pyramidalis*.

result of a reduction in accessible floodplain area rather than of a change in the numbers of animals using floodplain grazing. Accessible floodplain vegetation had a lower stocking density than off-floodplain vegetation during flood recession when pastures were still wet (Figure 6.4A) but was more densely stocked than off-floodplain areas one month after the flood peak (Figure 6.4A). Two months after the flood peak the overall stocking density of the floodplain was again higher than that of off-floodplain areas (Figure 6.4B).

Figures 6.3B and C show the seasonal trends in the amount of time animals spend grazing on each floodplain vegetation type. The amount of grazing of *C. dactylon* did not show any distinct seasonal trend, although the two months when this vegetation was used most were September, the driest month and February, when rising floods restricted access to low-lying floodplain vegetation (Figure 6.3B).

Most grazing in the low lying *E. pyramidalis* vegetation occurred in the dry winter months (May to September) but the relatively low use in summer was not caused by flooding in 1986 as floods occurred only in March, five months after the decline in use of the species (Figure 6.3B).

Use of floodplain fields and disturbed areas showed no seasonal trend, cattle only being excluded from these areas by the February 1986 floods (Figure 6.3B). The large numbers of cattle using fields during the summer crop growing period is unexpected, but it does not necessarily indicate a large amount of crop damage as many of the fields remain fallow.

Slightly more use of *C. fastigiatus* vegetation appears to occur in summer, but there is no distinct seasonal trend (Figure 6.3C). Use of *Phragmites* vegetation follows a pattern similar to the general pattern of use of the floodplain vegetation (Figure 6.3A and 6.3C respectively).

Considering the use of all vegetation types collectively (Figure 6.3A and 6.3B) it appears that the increase in the use of the floodplain as a whole during the winter months (Figure 6.3A) occurs principally because of increased use of *E. pyramidalis* although increased use of *C. dactylon* and *Phragmites* vegetation also contributes.

Seasonal trends in stocking density on accessible areas of each floodplain vegetation type are shown in Figure 6.4C and E, and stocking density on each vegetation type as a whole are shown in Figure 6.4D and F. These results show that for each vegetation type, the patterns of use of accessible areas are similar to the patterns of use of the area as a whole. The importance of this is that, with the exception of the month of a flood peak, use of floodplain vegetation of all types is not restricted by its inaccessibility.

A summary of daily herding practices is presented in Figure 6.5 (more detail is given in APPENDIX 3). During winter (June to September) less time was spent grazing than in summer and little time was spent grazing off-floodplain vegetation (Figure 6.5D and E). Cattle also spent more time resting at the homestead in winter than in summer (Figure 6.5A). The time cattle spent moving was consistently high (1.5 to 2.5 hours/day) throughout the year (Figure 6.5C).

In all surveys individual herds were observed to use floodplain pastures all day, or in the morning only. In summer (November to April) few cattle stay on the floodplain all day, but when conditions are driest in late winter (August and September) < 35 % of cattle leave the floodplain at mid-day (Figure 6.6).

6.3.3 The determinants of patterns of vegetation use

There are five main reasons why the floodplain is used more in winter than in summer:

a) During crop growth in summer cattle are excluded from floodplain areas with a high density of fields (APPENDIX 1: 2.5) whilst in winter, few floodplain areas are moist enough for crops and floodplain pastures are both accessible and acceptably dry.

b) For the short periods whilst water levels are high, floods restrict access to all vegetation types (Figure 6.4B).

c) Summer rains facilitate vegetation growth off the floodplain near the homesteads but in winter off-floodplain areas have sparse grazing and no water.

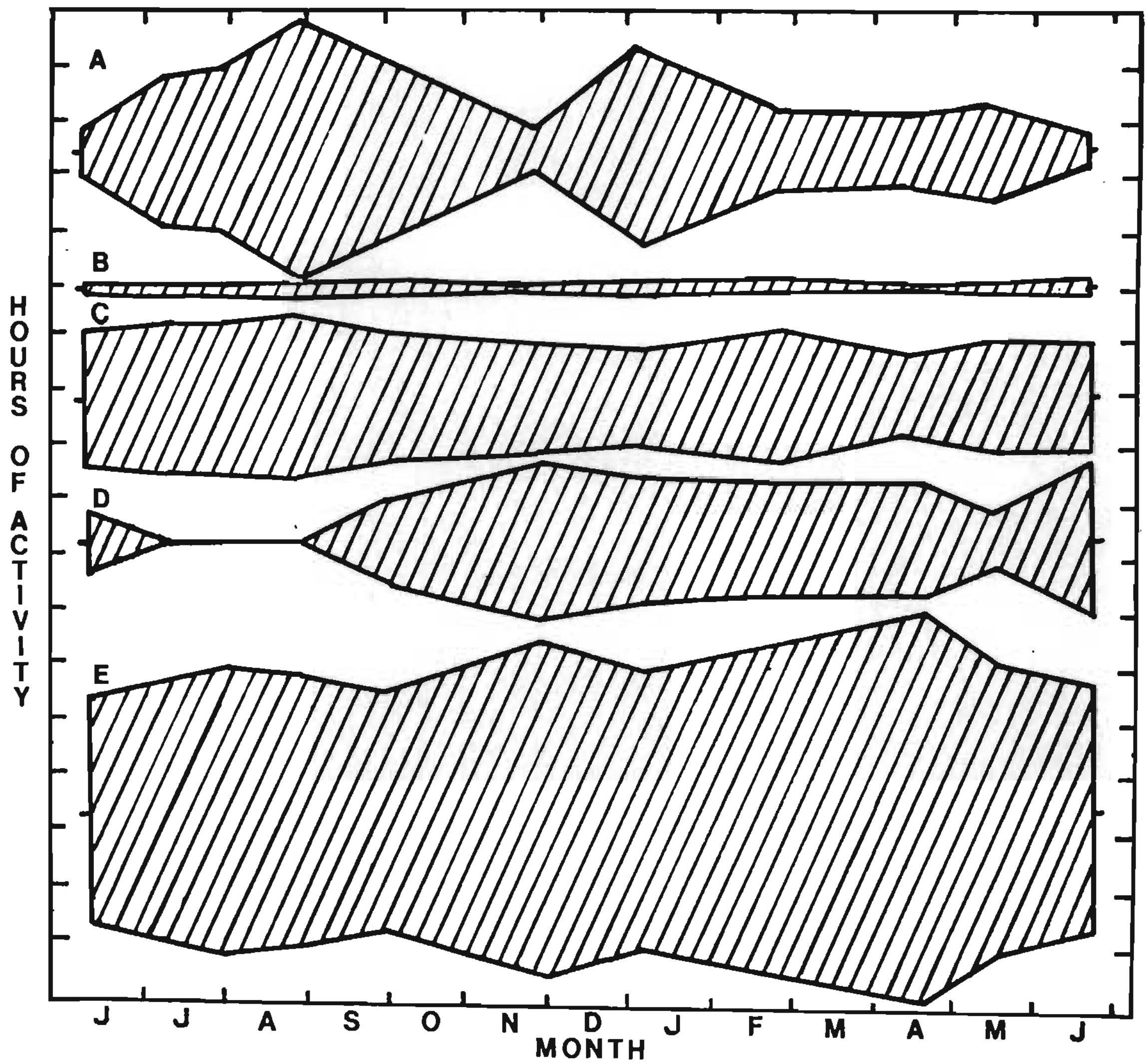

Figure 6.5 A summary of the daily activities of cattle on the Makatini flats. Shading indicates the time spent engaged in each activity. A = Resting at the homestead. B = At a water point/pan. C = Moving to pastures, water or the homestead. D = Grazing in off-floodplain areas. E = Grazing on the floodplain. N = 28 animals. Time spent penned at the homestead or ploughing by oxen has not been included (APPENDIX 3).

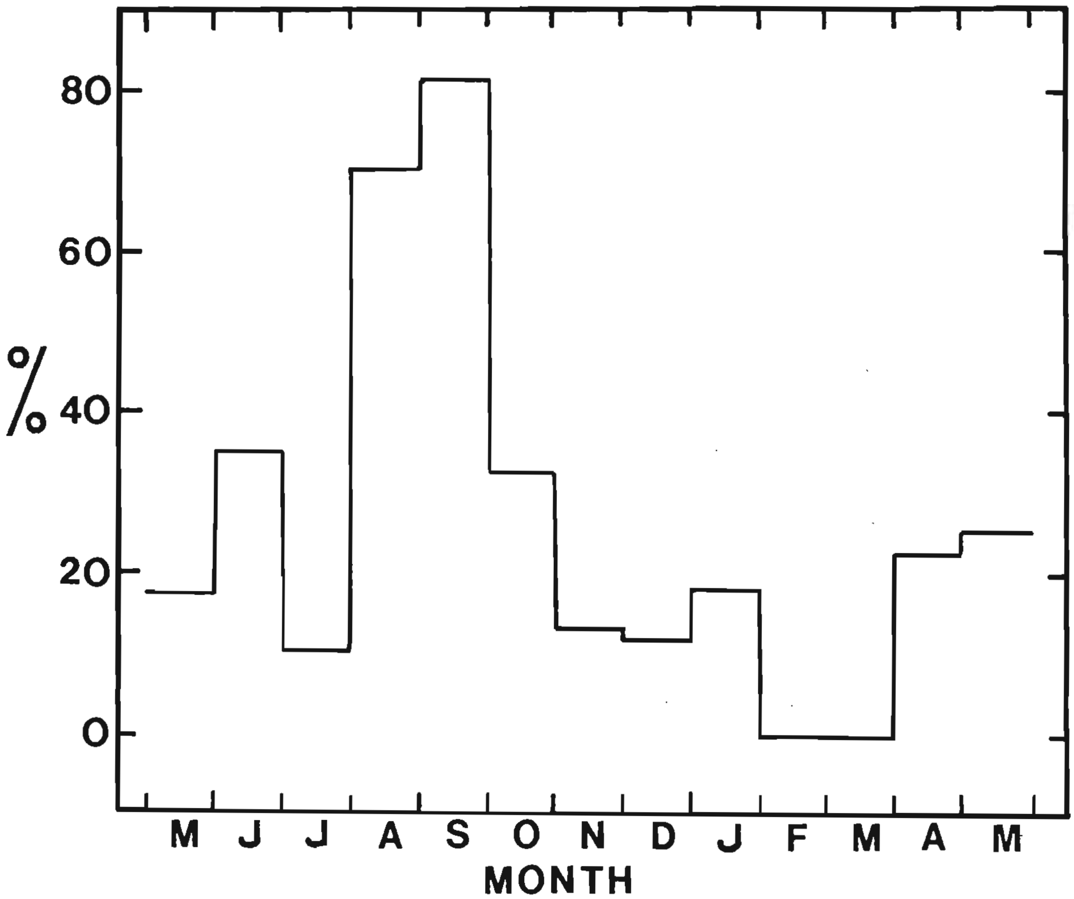

Figure 6.6 The percentage of cattle using Pongolo floodplain vegetation that remain on the floodplain to graze after 2.00 p.m. each day. Data from zones 2 and 3 (Figure 2.2, p.21). See text for methods.

d) There is increased use of *E. pyramidalis* vegetation in the dry winter period; the reason for which is discussed below.

e) More cattle return to the homestead at mid-day in summer than in winter; the reason for this is discussed below.

Cynodon dactylon is a short tough grass, less productive than *E. pyramidalis* (Furness, 1981; CHAPTER 6) and cattle appear to selectively graze *E. pyramidalis* or young *C. fastigiatus* in stands where these species grow near *C. dactylon* (pers. obs.). The high mean stocking density relative to other floodplain vegetation types probably occurs because *C. dactylon* occurs around pans and near the floodplain edge and because herding on short grass where cattle are easily seen is easy. Cattle are usually herded across *C. dactylon* when going to or from the floodplain or to watering points and frequently spend some time grazing during this process. The lawns are also used when collecting, sorting and counting cattle before returning home after herds have been grazing together in tall stands of *Phragmites* or *E. pyramidalis*.

The rapid autumn increase and spring decrease in use of *E. pyramidalis* occurs because this species causes scouring if grazed when wet and herders avoid it during rains or after floods (APPENDIX 1: 4). Once cattle enter *E. pyramidalis* stands, grazing and trampling facilitate rapid drying of the vegetation which becomes more acceptable as a result. High productivity of *E. pyramidalis*, even when heavily stocked, helps explain how a stocking density of 4 - 5 animals/ha can be maintained for four to five months in winter.

Phragmites australis and *Phragmites mauritianus* are both highly productive, (Gordon-Gray & Ward, 1971) but mature woody stems are not grazed. The period of greatest use coincides with the season when mature *Phragmites* stems are removed for building material (Cunningham, 1985) and soft new shoots are most accessible.

Cyperus fastigiatus only grows actively in the summer when conditions are wet. Once mature, plants have unpalatable, pithy shoots which makes access to lower leaves more difficult for cattle. By winter most plants are dead and their leaves are brittle. This explains why *C. fastigiatus*, unlike other floodplain vegetation, is not used more in winter than in summer.

No clear explanation for the patterns of use of agriculturally disturbed floodplain areas can be made because the type of vegetation available to cattle in these areas is highly variable. The area that is actually accessible was not determined and there are no distinct seasonal trends in its use.

Cattle owners and herd boys have two explanations for early returns to the homestead (CHAPTER 4 interview methods): either cattle were brought back for milking or herd boys were considered to be too young to stay out all day. The latter is not seasonally dependent but in late winter few cows are being milked (APPENDIX 2) and so few herders need to return cattle to the homestead for milking. Returning to the homestead at mid-day in summer does not mean that cattle will spend less time grazing since grazing occurs in off-floodplain vegetation in the afternoon. However, in winter animals that go home at mid-day do not usually graze in off-floodplain areas (Figure 6.6D, p.84), due to the lack of available forage. Seasonal trends in the proportion of cattle which do all their daily grazing on the floodplain can be partially explained by a reduction in milk production in winter, but the lack of grazing around the homestead in winter may also contribute.

Daily grazing periods are shorter in winter than in summer because day-length is shorter and the mornings are colder.

6.4 DISCUSSION

6.4.1 The importance of floodplain vegetation to the Makatini pastoral system

As only 23 % of grazing time in the study area is spent on the floodplain, and as the floodplain does not appear to be essential to the maintenance of cattle condition in the winter "stress period", access to floodplain vegetation cannot be considered vital to the maintenance of the Makatini pastoral system. Heeg and Breen (1982) state that the floodplain vegetation provides "an important winter supplement" to cattle on the Makatini flats and the results presented here support this thesis. However, the importance of the floodplain to cattle has been attributed to the use of *C. dactylon* meadows (Rogers, 1980; Furness, 1981; Slinger, 1988). This study shows that there is little seasonality in the use of *C. dactylon* and that it is mostly an increase in the use of *E. pyramidalis* that makes the floodplain more important in winter. The present importance of the floodplain lies in its use during winter and if, as is expected (CHAPTER 3), the number of animals in the area should increase and overstocking become a general problem, the importance of the floodplain in maintaining cattle condition will increase.

6.4.2 A comparison of the use of the Pongolo with the use of vegetation on other African floodplain systems

Many African floodplain systems are much larger than the Pongolo (Scudder, 1980; Drijver & Marchand, 1986). However, *C. dactylon*, *Echinochloa* and *Phragmites* species commonly form major stands on floodplains (Astle, 1965; Dean, 1967; Clayton, 1967; Vesey-Fitzgerald, 1970; Denny, 1985). The vegetation of the Pongolo is not, therefore, atypical and similar patterns of use would be expected.

Differences between the patterns of use on the Pongolo and other major African floodplains can mostly be explained by reference to the system's size. The movement of cattle onto the floodplain during the dry season is a characteristic pattern of use for African pastoral systems (Scudder, 1980; Drijver & Marchand, 1986). However, the Pongolo floodplain is small enough for cattle owners to live above the high flood level and still make use of the most distant vegetation along the river banks. The "daily migration" means that cattle spend several hours a day moving to and from grazing areas which are up to five kilometres from the homesteads. In large systems, such as the Sudd, stock are moved up to 100 km to reach winter pastures (Grandin, 1980) and a transhumerant or nomadic life-style must be adopted if grazing resources far from the system's edge are to be used.

The short flood duration on the relatively small Pongolo floodplain (CHAPTER 1) has several implications for the way in which the system is used. Flood recession takes several months (Fielder, 1973; Rees, 1978b; Grandin, 1980; Homewood & Rodgers, 1984) in large systems and patterns of vegetation use are determined largely by accessibility and animals move further onto the system and use different vegetation types as the system dries out. On the Pongolo most vegetation is accessible just one month after a flood peak. Consequently, most of the floodplain area can be grazed for ten or eleven months a year and a range of different vegetation types is usually accessible. The importance of access to a variety of vegetation types is shown by Rees (1978b) who found that the Kafue floodplain can only provide Lechwe with the nutrients they require if the animals can move freely between the different vegetation types.

In some larger systems, for example the Okavango delta (Campbell, 1976), floods occur during the local dry period, but because of the small size of the Pongolo system floods usually occur soon after local rainfall (CHAPTER 1).

As the Pongolo has similar vegetation to the larger systems but is more accessible to livestock it is suggested that, as a small system, it has a greater potential (per unit area) to provide grazing. Its small size also means that a nomadic life-style is not necessary for cattle owners to realise that potential.

6.4.3 Management of the Makatini pastoral system

This Chapter has dealt with the patterns of vegetation use on the Pongolo floodplain, but since cattle in the study area spend most of their time grazing in dry-land areas it is probably more important to understand and prudently manage the interaction between cattle and dry-land vegetation. On the floodplain maintenance of the area and productivity of *E. pyramidalis* is important and there is a need for an understanding of the interactions between river hydrology, grazing and *E. pyramidalis* crop growth (CHAPTER 7).

Furness (in press) estimated that the area of agriculturally disturbed land on the Pongolo floodplain increased by 97 % between 1976 and 1985 and because of this the low stocking density on disturbed floodplain areas relative to that of the natural plant communities is of concern to managers. New fields are usually cut from riverine forest (Heeg & Breen, 1982) and as these areas have a low mean stocking density relative to fields its destruction does not result in a loss of grazing. However, little riverine forest is left and in future new fields will have to be made in the more important grazing areas. Ways of minimising the loss to agriculture of floodplain vegetation ,and particularly *E. pyramidalis* and *C. dactylon*, need to be sought if these important grazing resource areas are to be maintained.

It has been established that floodplain vegetation is important principally as a "winter supplement" and any flooding regime that interferes with access to the floodplain in winter is undesirable. Flooding between November and March is recommended.

Although only the use of the floodplain as a whole has been discussed here, it should be noted that the management of the pastoral resources is probably best approached by considering each communal grazing area or "zone" (Figure 2.2, p.21) separately (CHAPTER 3).

6.4.4 Management planning and development of the Makatini flats

The high stocking densities on the Pongolo pastures give these areas a high value per unit area relative to both non-floodplain areas and in relation to profits from irrigated agricultural land (CHAPTER 5). Because of their high value, floodplain areas should be given special consideration in the development of the pastoral system and in regional planning for the Makatini flats.

As the patterns of vegetation use have been determined, the value of the Makatini pastoral resources can be included in a "resource value budget" for the area (Beaumont, 1985; CHAPTER 5). If it is assumed that without floods the value per hectare of floodplain vegetation would drop to the same as that of dry-land areas, the cessation of floods would result in an estimated reduction in grazing resource value of R 749 000/year. This is approximately 70% of the estimated value of Pongolo floodplain fisheries (CHAPTER 5).

A hydrological model of the Pongolo floodplain (Pitman & Weiss, 1979) has now been calibrated (Alexander & Roberts, in press) and it is possible to make fairly accurate predictions about how much water must be released from the Pongolapoort dam to raise floodplain water levels. The results presented here show that a loss of grazing resources valued at R 156/year will occur for every hectare of floodplain which is lost. This value must be offset by profits made from irrigated agriculture which uses water from the dam. The projected value of grazing resources lost if *E. pyramidalis* and *C. dactylon* are not flooded is R 523/ha/year and R 571/ha/year respectively.

6.4.5 Management planning for pastoral systems dependent on African floodplains

From the above discussion it is clear that an analysis of the patterns of pastoral resource use is important in planning the management of the Makatini pastoral systems because it ensures that the importance of specific grazing areas is understood, and that regional planners consider the use of grazing areas in the correct perspective. As the patterns of vegetation use on the Pongolo are similar to those on other African floodplains, it is suggested that a similar analysis of the patterns of pasture use would assist pastoral management planning elsewhere. Analysis of patterns of vegetation use will be most useful in management planning if the following questions are addressed:

a) Which areas/vegetation types are most used by cattle ? On the Pongolo researchers have tended to concentrate on grazing areas which provide only a small fraction of the forage (Furness, 1981; Slinger, 1988).

b) When is each of the vegetation types in the system used ? Differences in the pattern of use of each vegetation type on the Pongolo show that each area may play a different role in the pastoral system's functioning.

c) How dependent are cattle on specific vegetation types or grazing areas ? Although access to the Pongolo floodplain is not vital to cattle on the Makatini, failure to address this issue in other systems has had disastrous consequences (Kloos, 1982; Marty, 1983).

d) What determines the existing patterns of use ? *Echinochloa pyramidalis* is unsuitable for grazing when moist, yet in central Africa Cambrezy (1981) proposed more extensive use of marshes dominated by this species stating that "local cattle owners traditionally make little use of the marshes although there is no apparent reason why they should avoid it ".

e) What is the economic value per hectare of each vegetation type available to cattle ? The failure to estimate this value in the environmental impact study of the Pongolapoort dam (Heeg & Breen, 1979) resulted in cattle being excluded from the "resource value budget" used to plan development on the Makatini.

f) How much of a change in the value of wetland vegetation can be expected from modification of the area's hydrological regime ?

6.5 CONCLUSIONS

Access to the vegetation of the Pongolo floodplain does not appear to be vital to the maintenance of the Makatini pastoral system. However, stocking densities on the floodplain are higher than those in dry-land areas throughout the year (except during floods) and the floodplain forage is an important winter supplement. Increased use of floodplain vegetation in winter is mostly associated with the use of *E. pyramidalis* stands which are avoided in summer because they are moist and their use may cause scouring.

There are five important factors contributing to the determination of the seasonal patterns of floodplain use: the occurrence of an annual "stress period"; the fact that *E. pyramidalis* is more acceptable for use in winter; the absence of floods in winter; the reduced use of the floodplain for agriculture in winter and the reduced need in winter for cattle to return to the homestead at mid-day to be milked.

The seasonal patterns of vegetation use on the Pongolo floodplain are similar to those on the major African floodplains, but there are some differences which occur because the system is relatively small. Firstly, cattle owners need not adopt a nomadic life-style to make full use of the grazing resources since all pastures can be reached in a daily migration onto the floodplain.

Secondly, the short duration floods on the Pongolo make pastures more accessible and because of this its potential for fodder production is probably higher per unit area than that of larger systems.

The analysis of the patterns of vegetation use and the value of different grazing areas is important to the management of African pastoral systems and the integration of pastoral management into regional development planning. The analysis of the patterns of vegetation use in African pastoral systems should include: an estimation of how much each vegetation type is used, when each area is used, what the determinants of the patterns of use are and how dependent stock are on access to each area.

CHAPTER 7

EVALUATION OF THE GRAZING POTENTIAL OF *ECHINOCHLOA PYRAMIDALIS* (LAM.) HITCHC. AND CHASE.

7.1 INTRODUCTION

One objective of this thesis is to provide management recommendations for the Makatini pastoral system and for other traditional African pastoral systems which use floodplain vegetation. Although studies of local socio-economic structure, traditions and the patterns of vegetation use (CHAPTERS 2 - 6) are important, they do not provide an insight into how vegetation is best used or managed. Detailed analysis of the interactions between cattle and each of the vegetation types on the Makatini is beyond the scope of this study. However, *C. dactylon* and *E. pyramidalis* are the most important natural pastures on the Pongolo floodplain and as the growth dynamics of *C. dactylon* have been studied (Furness, 1981; Slinger, 1988) only the management of forage production in *E. pyramidalis* stands is discussed in this thesis.

Rangeland management is directed toward improvement of the quantity and quality of the forage produced and the literature about stocking density and different grazing systems is extensive (Tainton, 1981; Savory, 1983; Jung *et al.*, 1985; Watts *et al.*, 1987). In general, effective rangeland management depends on the manager's understanding of the relationships between pasture growth, grazing and animal production (Mentis, 1984; McDowell, 1985). The first issue addressed in this Chapter is how grazing or defoliation of *E. pyramidalis* affects crop growth rate.

In tropical pastures crop growth rate usually depends primarily on moisture availability (Strugnell & Pigott, 1978; Blair-Rains & Kassam, 1980) and rangeland management is usually concerned with rainfall/plant/animal interactions. In wetlands hydrology dictates system functioning (Etherington, 1983; Mitsch & Gosselink, 1986) and the combined effects of rainfall and hydrological regime on plant/animal interactions must be considered (Attwell, 1970). The second issue addressed is how flooding affects the crop growth rate of *E. pyramidalis*.

Rangeland managers are concerned with the manipulation of the system so that pastures provide for the nutritional requirements of stock and the third issue addressed in this Chapter is to determine the optimal stocking density of *E. pyramidalis* stands on the Pongolo floodplain. To do this the requirements of stock and the capacity of *E. pyramidalis* to provide those requirements must be determined.

Many environmental factors, other than forage quantity and quality, influence animal forage intake including; temperatures, frequency of watering, yarding practices and the physical condition of stock (Kyomo *et al.*, 1972; Webster & Wilson, 1980; Collier & Beede, 1985; Nashon *et al.*, 1987). Nutritional requirements are influenced by animal age, sex and condition (McDowell, 1985), milk production (Roy *et al.*, 1977), draught effort (Mathers *et al.*, 1985) and general activity (Kearl, 1982). Although the effects of these factors make determination of cattle's daily forage requirements difficult, tables from which estimates of the requirements of *Bos indicus* cattle in communal pastoral systems in the tropics can be made have been published (Roy *et al.*, 1977; Blair-Rains & Kassam, 1980; McDowell, 1985).

Energy, protein, minerals and vitamins are all important dietary components, but as animal requirements vary no precise nutritive value can be placed on forage samples (Mentis, 1981). There are a variety of ways in which forage quality can be assessed, digestibility probably being the most useful single parameter (Mentis, 1981; Zacharias, 1985). However, digestibility is poorly correlated with animal performance parameters such as average daily gain ($r^2 = 0.52$: Clark & Barth, 1970) and energy followed by protein content are the most common factors which limit animal production (Roy *et al.*, 1977; McDowell, 1985). In this study of the potential of *E. pyramidalis* vegetation as a source of forage, its digestibility, and protein and energy content are determined and compared with estimated animal requirements.

Echinochloa species are common floodplain grasses throughout Africa (Rees, 1978b; Vesey-Fitzgerald; 1970; Furness, 1981; Stormanns, 1988) and their value as productive pastures has been recognised (Cambrezy, 1981; Morton & Obot, 1984). In this Chapter interactions between hydrology, rainfall, grazing and the crop growth rate and quality of *E. pyramidalis* forage are examined with a view to establishing guidelines for the management of *E. pyramidalis* stands for grazing on the Pongolo and elsewhere.

7.2 METHODS

7.2.1 Quantitative assessment of production and grazing rates

Mature *E. pyramidalis* stands on the Pongolo floodplain consist of two distinct strata: a lower, non-grazeable stratum comprising a dense mat (0 - 0.4 m deep) of fallen stems with adventitious roots, fine fibrous roots and the bases of erect stems, and an upper, grazeable stratum, consisting of erect stems and leaf blades (0 - 2.5 m high). After a flood roots appear to grow mostly in the lower stratum and only penetrate the substratum when the lower stratum moisture content is approximately 55 % or less.

Crop growth rate (Kg/ha/day) and grazing rate (Kg/ha/day) were determined at three-weekly intervals for one year in an eight hectare mono-specific *E. pyramidalis* stand located near Namanini pan (Figure 2.2, p.21). Six 3.5 m by 1.5 m movable wire exclosures were randomly placed in the stand. In each exclosure a plot 1 m^2 (2.0 x 0.5 m) was clipped three weeks after the exclosure's placement. Six similar plots outside the exclosures were also clipped before the exclosures were moved and the procedure repeated. Plot shape was selected to reduce effects of patchiness, caused by uneven grazing, on sample size (Van Dyne *et al.*, 1963; Milner & Hughes, 1968). Sampled sites were marked to prevent resampling of the same site.

Grazeable and non-grazeable fractions were sampled separately. Each sample fraction was weighed, dried at 60 °C to constant mass and then re-weighed. Standard errors of the mean for the six sample replicates never exceeded 12 % for either grazeable or non-grazeable fractions. Rates of dry mass production and grazing were calculated using the methods described by Brown (1954), Kerby and Gosselink (1976) and Hunt (1978). Insect grazing was not accounted for (Caldwell, 1975).

Clipping and grazing do not to have exactly the same effect on plants (Barnes, 1976) but as controlled grazing experiments were not possible in this study, clipped quadrats were used to provide an indication of the crop growth rate and forage quality of defoliated plants. Crop growth rate (Kg/ha/day) of defoliated *E. pyramidalis* was assessed using clipped quadrats (Culley *et al.*, 1933). An apparently representative and uniform 0.12 ha area of the

E. pyramidalis stand was fenced and thirty 2 by 2 m plots were marked out. All grazeable material was clipped from plots approximately one week after the recession of flood waters. Thereafter, ten randomly located plots were clipped at 14 day intervals, ten at 28 day intervals and ten at 42 day intervals. The experiment was run for 84 days. Only the material from a 0.5 by 0.5 m quadrat in the centre of each plot was used in the analysis, but the whole plot was clipped, leaving a 0.75 m border for edge effects.

7.2.2 The effects of flooding and rainfall on moisture availability

Rain gauges were set up near the study site and soil moisture was determined from samples taken with a 10 cm diameter auger from each vegetation sample site. Plant moisture content for upper and lower vegetation strata were determined using methods described by Furness (1981).

7.2.3 Animal nutritional requirements

Requirements for forage mass, digestibility, digestible energy and protein content were estimated using nutrient requirement tables (Roy *et al.*, 1977; Blair-Rains & Kassam, 1980; McDowell, 1985). Tables were read according to animal size, activity (amount of walking to pastures and hours of work done by draught stock; Boudet & Riviere, 1968) and milk yields recorded during the 1985/1986 study (CHAPTERS 2 - 6).

7.2.4 Forage quality determination

Digestibility was assessed using an *in vitro* two stage digestion (Tilley & Terry, 1963; Zacharias, 1985). The sample replicates from the quantitative assessment (7.2.1) were bulked and milled and enough digestions were performed to obtain a s.d. of < 10 % of the mean (3 - 5 replicates).

Bulked and milled quantitative samples (7.2.1) were analysed using bomb calorimetry to determine pasture energy content. Crude protein content of the same samples was determined by multiplying nitrogen content (determined using spectroscopy) by 6.26 (Roy *et al.*, 1977; McDowell, 1985). Three replicate analyses per sample ensured a s.d. of < 10 % of the mean.

7.3 RESULTS

7.3.1 The effects of grazing on *Echinochloa pyramidalis* growth rate

Grazing took place over a four month period in winter (Figure 7.1A) and except during this period, the standing crop of grazeable material remained high (Figure 7.1B). Crop growth rate and relative growth rate were both low (< 30 Kg/ha/day and < 15 g/Kg/day respectively) when standing crop was high but increased when grazing took place and the standing crop declined (Figure 7.1A and 7.1B).

In March flooding caused the collapse of stems and negative growth rates were recorded (Figure 7.1C) but there was no increase in lower stratum standing crop (Figure 7.1B), probably because the flood caused decay and removal of material from the non-grazeable stratum. Negative values for growth rate were recorded again in late September because winds caused tall, grazeable shoots in exclosures to collapse. The increase in standing crop in the non-grazeable stratum in September provides evidence for the collapse (Figure 7.1B).

Between October and January relative growth rate (Figure 7.1C) declined as standing crop increased (Figure 7.1B), but crop growth rate (Figure 7.1C) was highest in November/December when the grazeable stratum standing crop was between 3 000 and 5 000 Kg/ha (Figure 7.1B). Cattle only started to graze in the *E. pyramidalis* stand 160 days after a flood (Figure 7.1A) during the season of low rainfall (Figure 7.1D) yet crop growth rate was highest during the grazing period (Figure 7.1C). It appears then, that grazing, or defoliation, is a major determinant of *E. pyramidalis* crop growth rate on the Pongolo and in its absence, a rise in standing crop to > 5 000 Kg/ha inhibits further growth.

7.3.2 *Echinochloa pyramidalis* forage production potential

The crop growth rates of clipped *E. pyramidalis* plots are shown in Figure 7.2A. In the first 42 days, plots that were not reclipped produced the most forage, and quadrats clipped every 14 days produced the least, although the latter showed a trend of increasing growth rate during this period (Figure 7.2A). Crop growth rates after day 42 of the experiment were lower

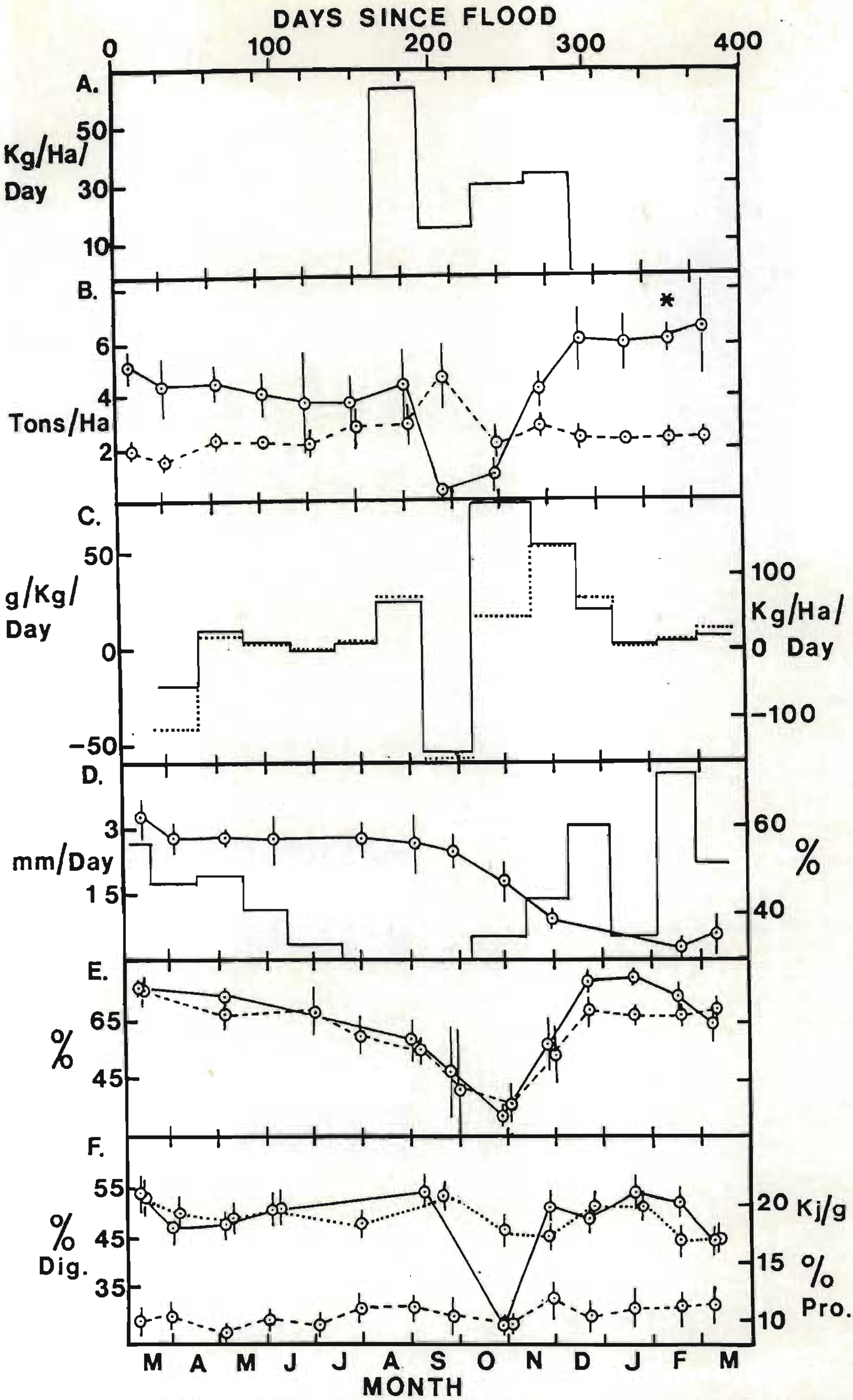

Figure 7.1 Conditions in an *E. pyramidalis* stand near Namanini pan during 1985/1986. Days are from the date of flood recession. All vertical lines are 2x s.e. . * indicates the time of flowering. A; grazing rate. B; standing crop of non-grazeable, - - -, and grazeable, ——, plant parts. C; crop growth rate (Kg/ha/day), ····, and relative growth rate (g/Kg/day), ——, of grazeable plant parts. D; monthly rainfall, (boxed) and soil moisture content. E; the moisture content of grazeable, ——, and non-grazeable, - - -, plant parts. F; forage quality; % digestibility (% Dig.) ——, % crude protein (% Pro.) - - -, and energy content ····.

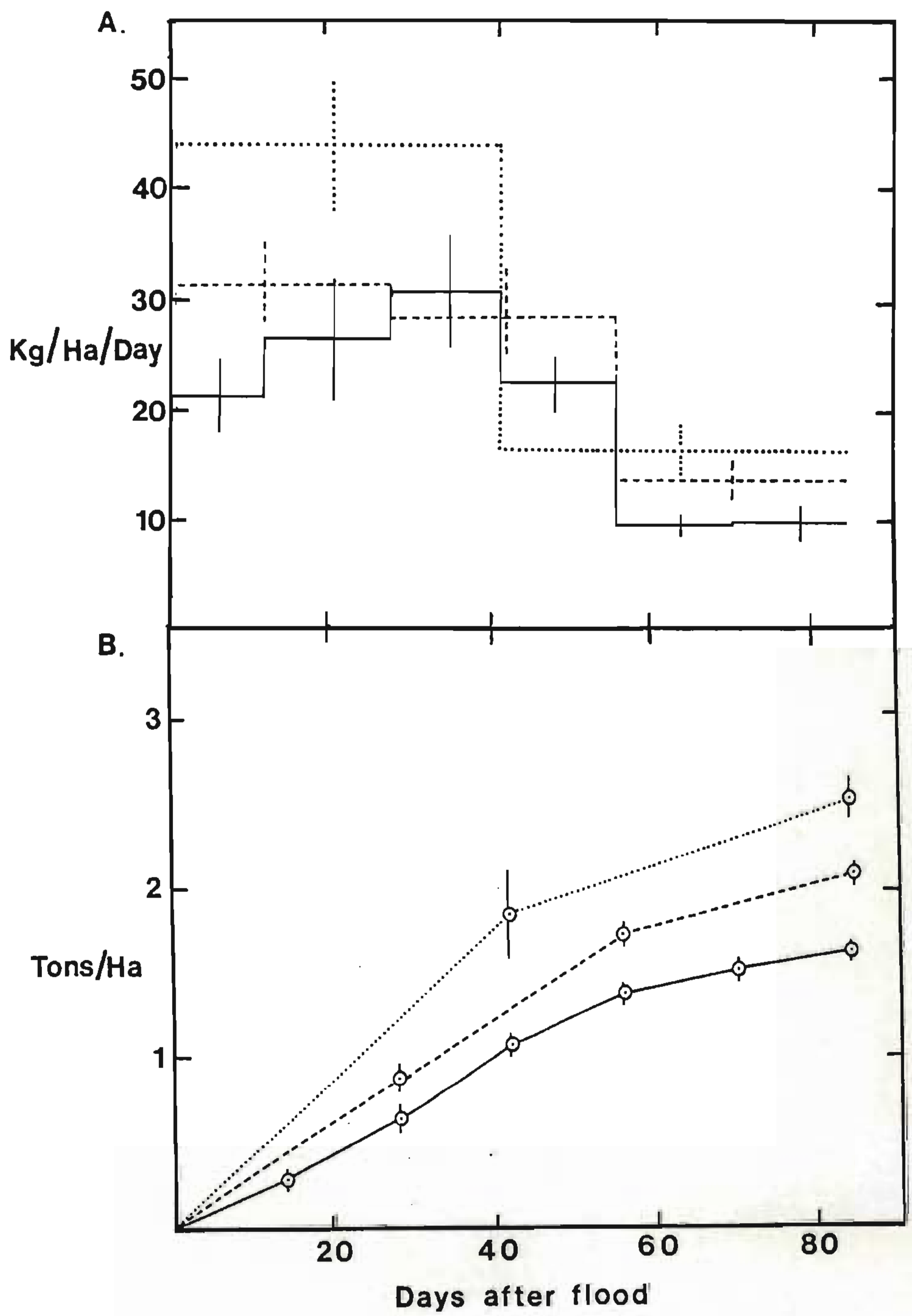

Figure 7.2 Crop growth rate: A, and accumulative production of grazeable material: B, in an *E. pyramidalis* stand under three defoliation treatments; Clipped every 42 days, ····, every 28 days, - - -, and every 14 days, ——. Vertical lines are 2x s.e.. Units are of dry mass.

than they had been in the first 42 days for all treatments and there was no significant difference ($p = < 0.05$) between treatments, although quadrats clipped every 14 days again resulted in the lowest crop growth rate (Figure 7.2A). It appears that in the 42 days after a flood more forage is produced if plants are defoliated only once than if defoliation occurs two or three times. However, between 42 and 84 days after a flood defoliation every 28 days does not reduce crop growth rate. The quantity of material removed from clipped quadrats increased significantly with an increased interval between clippings (Figure 7.2B) which indicates that for greatest forage production plants should not be defoliated more than once every 40 days.

The highest crop growth rate attained in clipped quadrats occurred in the first 42 days after a flood and in quadrats which were not clipped during this period (Figure 7.1A). The average standing crop in these quadrats (half the mass of forage produced during a time interval) was about 900 Kg/ha and all the more frequently clipped quadrats had a lower standing crop. These results lead to the suggestion that stands are most productive when they have a standing crop > 900 Kg/ha .

The crop growth rate in all clipped treatments declined as the time from flooding increased, although soil moisture content remained high and good rains fell during this period (Figure 7.1D; March, April and May). Plant moisture content in clipped quadrats was not monitored, but the moisture content in both strata in grazed zones declined when the standing crop of the grazeable stratum declined (Figure 7.1B and 7.1E). From this it appears that defoliation enhances drying of the lower stratum and may thus reduce crop growth rate. Another possibility is that repeated defoliation reduces plant vigour.

It is not clear whether either of these factors is important. A reduction in crop growth rate caused by drying seems unlikely because the highest relative growth rate recorded in grazed stands occurred in the month when plant moisture content was lowest. A reduction in crop growth rate caused by defoliation seems unlikely because the highest crop growth rate recorded in either clipping or grazing experiments occurred after three months of grazing. The clipping experiment was done in autumn and progressively declining temperatures provide one possible explanation for the decline. This is important because it leads to the suggestion that *E. pyramidalis* stands do not require repeated wetting every few months to maintain productivity and repeated defoliation for periods of three months do not appear to reduce plant vigour.

7.3.3 The importance of flooding and rainfall

Soil moisture only started to decline six months after the flood (Figure 7.1D) but the moisture content of the non-grazeable stratum declined gradually from the time of the flood until the new season's rains started in October/November (Figure 7.1D) when it started increasing again (Figure 7.1E). The moisture content of the grazeable stratum followed the trend in moisture content in the lower non-grazeable stratum (Figure 7.1E) and not that of soil moisture (Figure 7.1D). From this it appears that rainfall can maintain sufficiently high moisture levels in the non-grazeable stratum for high forage production in summer. However, at least one flood per year is required to maintain high soil moisture content (> 35 %), which is probably necessary for the continued dominance of *E. pyramidalis* in the stand in the long-term (Furness, 1981; Stormanns, 1988).

The extent to which the lowering of the grazeable stratum standing crop by grazing (Figure 7.1B and 7.1A respectively) contributed to the decline of soil moisture (Figure 7.1D) is not known, but as the decline started in September it seems likely that the low standing crop did contribute.

7.3.4 Pasture quality

The crop growth rate and total mass of digestible forage produced in clipped quadrats is shown in Figure 7.3A and 7.3B respectively. Trends in dry mass production (Figure 7.2) and digestible dry mass production (Figure 7.3) were similar because there were only small differences in forage digestibility between clipping treatments (Table 7.1). Quadrats clipped every 42 days produced significantly more digestible forage than quadrats clipped more frequently (Figure 7.3B). The quantity of digestible forage produced in quadrats clipped every 28 days only became significantly greater than that produced in those clipped every 14 days once the experiment had run for more than 56 days (Figure 7.2B).

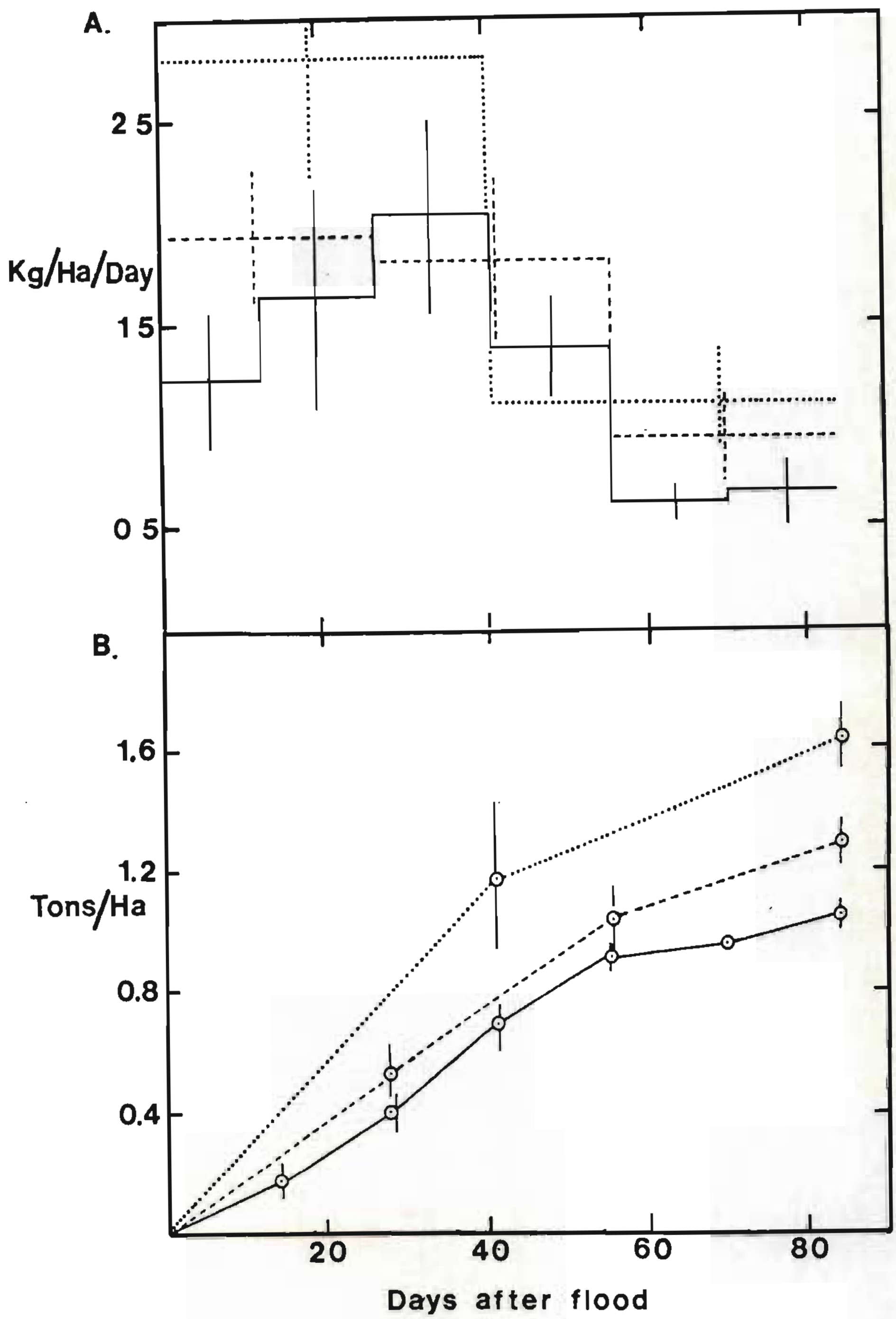

Figure 7.3 Crop growth rate: A, and accumulative production of digestible grazeable material: B, in an *E. pyramidalis* stand under three defoliation treatments; Clipped every 42 days, ····, every 28 days, - - -, and every 14 days, ——. Vertical lines are 2x s.e.. Units are of digestible mass (the product of digestibility and dry mass).

Table 7.1 The digestibility, energy and crude protein content of *E. pyramidalis* from clipped quadrat samples. Time = time between the sampling date and the start of the experiment. Sampling interval = time between clippings.

	DIGESTIBILITY (%)			ENERGY (Kj/g)			PROTEIN (% dry mass)		
TIME	SAMPLING INTERVAL			SAMPLING INTERVAL			SAMPLING INTERVAL		
Weeks	Two	Four	Six	Two	Four	Six	Two	Four	Six
2	60.4	-	-	19.4	-	-	15.0	-	-
4	63.5	61.5	-	19.1	18.5	-	15.5	13.0	-
6	67.1	-	64.4	18.6	-	19.6	15.9	-	11.9
8	63.6	62.9	-	17.5	18.4	-	15.1	13.4	-
10	67.9	-	-	21.5	-	-	17.3	-	-
12	72.0	69.6	69.7	20.1	18.8	16.4	17.0	15.7	15.4

In the defoliation experiment, energy and crude protein content showed little change with increased time from flooding or with different clipping treatments (Table 7.1) and both were well above the minimum required for maintenance of animal body weight; a minimum of 7.5 - 12 Kj/g energy and 5 - 8 % crude protein (Table 7.2; Boudet & Riviere, 1968). The importance of this is that it shows that *E. pyramidalis* forage is of a high quality and that its quality is not reduced by defoliation.

The energy and crude protein content of forage appears to be affected little by season, changes in plant moisture content (Figure 7.1E) or changes in grazeable stratum standing crop (Figure 7.1B) and remained constant during the grazing experiment (Figure 7.1F). The digestibility of forage was high throughout the year (Figure 7.1F) except when the grazeable stratum standing crop declined during grazing (Figure 7.1A and 7.1B). The low digestibility of forage in the heavily grazed plots probably arose because samples were taken from grazeable material left after grazing had occurred. The samples consisted mostly of stems and included very few of the young leaf blades which cattle eat. It appears then, that the quality of the forage available to cattle remains consistently high throughout the year despite the seasonality of rainfall, flooding or grazing rate.

7.3.5 Animal forage requirements

Table 7.2 shows the estimates of daily forage requirements for stock on the Makatini. With the exception of the digestible energy requirement, estimates from the three sources are similar and, therefore, the mean value is probably reliable. The estimates made are for forage eaten but as some loss of forage will occur because of trampling, the total forage requirement of animals will be higher. Rees (1978c) estimated that 16 % of forage in similar wetland pastures on the Kafue floodplain was lost through trampling and Laycock *et al.* (1972) state that a loss of up to 40 % may occur in pastures susceptible to trampling. The values given probably under-estimate the amount of forage that cattle need by about 15 - 30 % .

Table 7.2 Daily fodder requirements of cattle on the Makatini flats as determined from tables supplied by three authors.

AUTHOR	REQUIREMENTS			
	DRY MASS (Kg/AU/day)	DIGESTIBLE ENERGY (Mj/AU/day)	DIGESTIBLE CRUDE PROTEIN (Kg/AU/day)	MINIMUM CRUDE PROTEIN (% of dry mass)
Roy *et al.*, (1977).	6.0 - 7.5	47	0.18 - 0.28	5 - 7
Blair-Rains & Kassam, (1980).	6.25	63	0.16 - 0.47	6.5
McDowell, (1985).	4.5 - 7.6	70	0.27 - 0.52	8.5
MEAN ESTIMATE OF REQUIREMENTS	6.3	60	0.31	7.5

7.3.6 The potential of *Echinochloa* stands as a source of cattle food

Table 7.3 shows the estimated potential production of dry matter, digestible crude protein, digestible energy and the crude protein content of forage in *E. pyramidalis* stands as a summary of the results presented above (7.3.1 - 7.3.5). After subtracting 25 % for losses due to trampling (7.3.5) values in Table 7.3 were divided by the values given for animal requirements (Table 7.2) to obtain the estimates of "carrying capacity" presented in Table 7.4. The three estimates of "carrying capacity", based on the quantity, digestible energy and digestible protein content of forage are similar (Table 7.4). As the quantity of forage produced changes under different stocking densities (Figure 7.1) but the quality of forage available remains constant (7.3.4) it seems that the quantity rather than the quality of *E. pyramidalis* forage is the principal determinant of the number of animals that *E. pyramidalis* stands can support.

7.4 DISCUSSION

7.4.1 *Echinochloa pyramidalis* forage production potential

Crop growth rates of between about 45 Kg/ha/day in spring and summer and about 20 Kg/ha/day in autumn and winter can be expected. If pastures are heavily grazed and standing crop reduced to below 1 000 Kg/ha, crop growth rate will probably drop to between about 30 Kg/ha/day in spring and summer, and about 15 Kg/ha/day in autumn and winter. Once standing crop exceeds 5 000 Kg/ha production does not contribute to any increase in the amount of fodder. Tall stems are susceptible to falling in the wind and use of the fodder is wasteful because cattle trample more forage than when stems are shorter.

Despite long periods of low crop growth rate during the grazing exclosure experiment, 11 750 Kg/ha/year of forage was produced and about 4 500 Kg/ha/year was grazed. The high production occurred because average crop growth rate over five months during grazing was 69 Kg/ha/day. This means that crop growth rates of 45 Kg/ha/day in summer and 20 Kg/ha/day in winter are probably underestimates of the stand's forage production potential. Estimates based on the grazing data only (i.e. without reference to the clipped quadrat experiment) lead to the suggestion that a year-round potential

Table 7.3 A summary of the estimated production capabilities and quality of forage in *Echinochloa pyramidalis* stands on the Makatini flats. Estimates of the quantity of forage produced were based on results from the clipped quadrat experiment (Figure 7.2A, p.99).

SEASON	ESTIMATED FORAGE PRODUCTION			
	DRY MASS Kg/ha/day	DIGESTIBLE ENERGY Mj/ha/day	DIGESTIBLE CRUDE PROTEIN Kg/ha/day	MINIMUM CRUDE PROTEIN % of dry mass
SUMMER	45	430	2.5	11
WINTER	20	190	0.9	9

Table 7.4 The estimated "carrying capacity" of *Echinochloa pyramidalis* stands on the Pongolo floodplain based on the quality and quantity of forage produced (Table 7.3) and an average animal's daily requirements of A, forage mass; B, digestible energy; and C, digestible crude protein (Table 7.2). A loss of 25 % of forage due to trampling was assumed (7.3.5, p.104).

SEASON	CARRYING CAPACITY (AU grazing days/day/ha)		
	A	B	C
SUMMER	5.3	5.4	6.1
WINTER	2.5	2.4	2.2

crop growth rate of 70 Kg/ha/day could be attained under a suitable grazing policy. This would yield approximately 23 000 Kg/ha/year dry mass of forage and the estimated "carrying capacity" would be double that quoted above.

Whether realised or potential forage production estimates are used, *E. pyramidalis* is highly productive relative to other African floodplain pastures; about 3 950 Kg/ha/year for *C. dactylon* (Furness, 1981); 2 400 - 8 000 Kg/ha/year (mean 5 560) for 10 floodplain species on the Kafue floodplain (Rees, 1978c) and the 3 000 - 8 000 Kg/ha/year estimate for African floodplains (Blair-Rains & Kassam, 1980).

7.4.2 Recommended stocking system

The restriction of *E. pyramidalis* grazing on the Pongolo floodplain to a four month period in winter and spring is related to the condition of other pastures, the agricultural cycle, and the acceptability to cattle of *E. pyramidalis*. Cattle owners complain of scouring in cattle that graze exclusively on *E. pyramidalis* with a high moisture content (CHAPTER 5). It is recommended, therefore, that cattle spend some time grazing other, drier vegetation each day when *E. pyramidalis* forage with a high moisture content is being used.

Grazing appears to reduce the moisture content of the pasture, so if pastures are continually grazed a reduction in scouring problems can be expected. To prevent development of mature stands which have a low crop growth rate, are unacceptably moist and the grazing of which results in increased trampling of forage, a continuous grazing system is recommended.

7.4.3 Recommended stocking density

To ensure a high crop growth rate *E. pyramidalis* stands should be maintained at between 1 000 and 5 000 Kg/ha standing crop. In the dense stands on the Pongolo floodplain this corresponds to a height of 0.3 - 1.0 m . Under these conditions crop growth rate will be high and the grazeable stratum will also provide some protection for the non-grazeable stratum against desiccation during dry periods.

A stocking density of 2 - 3 AU/ha in winter and 4 - 5 AU/ha in summer does not seem unreasonable for *E. pyramidalis* pastures on the Pongolo floodplain as long as herders move stock frequently to ensure even use of the pastures. When forage is of a high quality stock tend to increase their daily intake (Conrad *et al.*, 1966; McDowell, 1985) and, therefore, fewer animals could probably use the forage produced in *E. pyramidalis* stands. If this occurred, animal performance (daily weight gain, milk production, draught energy output) would be expected to increase. It should be noted that the mean stocking density on *E. pyramidalis* stands in 1985/1986 was estimated at 2.2 AU/ha but that most grazing occurs in winter when the highest stocking density (4.5 AU/ha) was recorded (CHAPTER 6).

7.4.4 Recommended flooding regime

Work by Furness (1981) on the Pongolo, and Stormanns (1988) on the adjacent Mkuzi floodplain, indicates that the hydrological regime and soil moisture conditions are the primary determinant of plant species distribution. *Echinochloa pyramidalis* is a wetland species and its dominance in certain low-lying inter-pan areas of the Pongolo floodplain is the result of a particular set of soil and moisture conditions. Alteration of the natural flooding regime, normally one to three short-duration floods in summer (Heeg and Breen, 1982; Figure 1.5B, p.11), would change these conditions and increase the probability of alteration of the species composition in the stands. Because of the high productivity and quality of *E. pyramidalis* forage this is undesirable.

A flood occurring prior to the dry season will maintain moist conditions in *E. pyramidalis* stands for much of the year. If a flood occurred in March, the pastures would be inaccessible during their summer flowering period (Figure 7.1B, p.98) and access to the pastures during winter and spring, when other pastures are in short supply, would not be interferred with. One flood, in late March each year, is considered necessary for the maintenance of short-term plant production/animal interaction. One flood annually is, however, less than would be expected under natural conditions and a second flood in December would be desirable to ensure maintenance of *E. pyramidalis* dominance and productivity in the long-term. If the grazeable stratum standing crop is kept low by continuous grazing, this may lead to a drying out of the stand and as plants root into the soil under these conditions, more than one flood annually would probably be needed to maintain productivity of heavily and continuously grazed *E. pyramidalis* vegetation.

7.5 CONCLUSIONS

The forage production potential of *E. pyramidalis* is high compared with that of other floodplain vegetation and plants will grow throughout the year if continually grazed or defoliated. The quality (digestibility and protein content) of forage remains high throughout the year although the vegetation may become unacceptably moist for grazing in summer. Grazing reduces the moisture content of plants, making the forage more acceptable.

Flooding events are not primarily important for the maintenance of crop growth rates during summer, when rainfall can maintain moist conditions in the non-grazeable stratum or root zone. However, at least one flood in late summer is required each year to maintain plant and soil moisture through winter and long-term maintenance of species composition in stands depends on the maintenance of the natural flooding regime. If continuous grazing were to result in a constantly low (< 1 000 Kg/ha) grazeable stratum standing crop, a second flood annually would probably be needed to maintain a high crop growth rate.

A continuous grazing system or frequent (monthly) return of cattle to pastures to maintain a standing crop of about 3 000 Kg/ha (grazeable stratum about 40 cm high) is recommended. This corresponds with a stocking density of about 4.5 AU/ha in summer and 2.5 AU/ha in winter. There are indications that higher stocking densities may be acceptable. It is recommended that cattle be moved onto drier vegetation for part of each day as exclusive use of *E. pyramidalis* forage may cause scouring.

Implementation of the recommended grazing system would not require any structural alteration of the present pastoral system (CHAPTERS 2 - 6) although stock owners would have to be persuaded to herd cattle onto moist *E. pyramidalis* in summer in preference to grazing the acceptable forage available close to their homesteads.

CHAPTER 8

GENERAL DISCUSSION

8.1 INTRODUCTION

The foregoing Chapters of this thesis have dealt with different aspects of the Makatini pastoral system, and management recommendations have been made where applicable. Now, though the information on the pastoral system is far from complete, and some basic data are still not available, what is needed is a synthesis of the information presented, the identification of the broader issues of management and the establishment of some general recommendations.

How we manage "systems" depends on our perception of their context and structure (CHAPTERS 2 - 6). Bowonder (1987) states that perception plays a major role in environmental decision-making and he recognises three types of perspective; personal, technical and organisational. He claims that perceptual level determines the way in which people respond to environmental management problems and suggests that these problems are best tackled using multiple perspective analysis, as conceptualised by Linstone (1981a; 1981b; 1984). Linstone's proposal is that systems be considered on different scales and from the viewpoint of different interest groups (CHAPTER 5, p.51).

Interest groups who are to be represented in management must be identified and the system's context or environment understood (CHAPTERS 1 and 2) before management recommendations can be made. In this Chapter management problems are considered and recommendations made in the context of the perceptions of the two main groups concerned with pastoral resources on the Makatini flats.

8.2 THREATS TO THE MAINTENANCE OF THE MAKATINI PASTORAL SYSTEM

The principal objective of the management of the Makatini pastoral system is seen in this study as the improvement of the sustainable yield of benefits from cattle to cattle owners within the existing socio-economic context over a time scale of 1 - 50 years. The management options identified and the recommendations made are based on an attempt to achieve this objective and may, therefore, be contrary to other potentially acceptable management objectives for the system.

Management issues can be considered as synonymous with potential or realised threats to the attainment of objectives, or with opportunities to increase the value of utilities provided. Factors which have the potential to affect maintenance or improvement of the value of cattle and pastures to cattle owners adversely are "threats" and are of concern to pastoral development planners. "Threats" identified in this study are listed in two categories: those particular to the structure of the system (internal threats) and those caused by factors external to, or administered beyond the geographic boundaries of the study area (environmental threats). Problems have been marked (P) or (p) for potential and (E) or (e) for existing. (P) and (E) indicate threats that the author considers to be of major importance and (p) and (e) denote less important issues. The list below provides a summary of the issues which arise from findings presented in other Chapters.

8.2.1 Internal threats

8.2.1.1 Overstocking

The symptoms of an overstocked pastoral system are shown in Figure 8.1 . Overstocking is caused by high animal numbers relative to the supply of suitable forage (Noy-Meir, 1975; White, 1978) and occurs either when animal numbers increase or when the quality and quantity of available forage declines.

Stock holdings in the study area are increasing (CHAPTER 3) and factors which may contribute to this increase are:

a) The "tragedy of the commons" or land tenure system (e; P) (CHAPTER 3).

b) The high value of non-marketed utilities (e; p) (CHAPTER 5).

c) The high rate of return from cattle, even in a degraded traditional pastoral system (e; p) (CHAPTER 5).

d) The high human population growth rate (E; P).

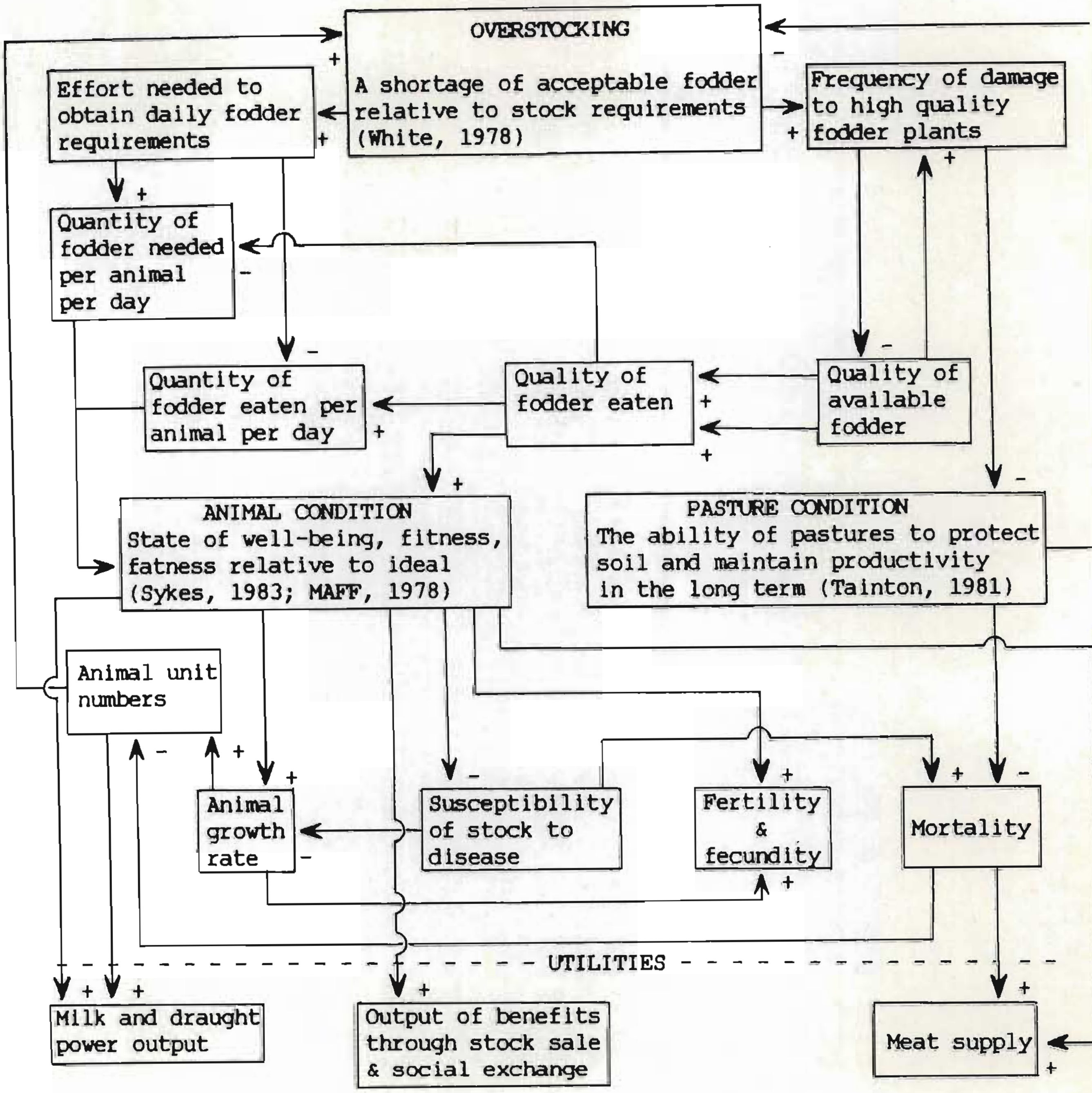

Figure 8.1 A flow chart showing the major interactions which link overstocking and utility values in the Makatini pastoral system. Arrows show the direction of effects. + and - are positive and negative effects respectively.

The human population in the study area (Figure 1.2, p.7) doubled between 1975 and 1986 (KwaZulu Government Department of Health, unpublished records). This factor does not necessarily contribute directly to overstocking, but in KwaZulu cattle population densities are more closely correlated with human population densities than regional rainfall or recommended stocking densities (Bonsma *et al.*, 1950).

Factors contributing to a reduction in the quality and quantity of forage available to stock are:

a) Increased human population and an associated demand for subsistence or small scale commercial agricultural land (E; P).

The area of agriculturally disturbed land off the floodplain increased by approximately 10 % between 1976 and 1985 (Furness, in press) but as only about 11 % of off-floodplain land in the study area is being used (data from Furness, in press), this does not seem to be an important threat. A 97 % increase in the area of agricultural land on the floodplain occurred in the same period and disturbed areas now constitute more than 50 % of the floodplain grazing area. Replacement of natural vegetation types (Table 8.1) has caused a decline in both the quantity and quality of forage produced (Buchan, in prep.).

b) Overgrazing (e; P)

The study area has a high stocking density (CHAPTERS 1, 3 and 6) and changes in floral composition of floodplain vegetation have occurred (Breen, C.M., 1987, pers. comm.; Table 8.1). The extent to which changes in plant community areas have been caused by grazing is not clear, but it seems likely that grazing has contributed (Breen, C.M., 1987, pers. comm.).

c) Reduced access to pastures (e; P)

Furness (in press) reported an intensification in the use of existing fields on the floodplain between 1976 and 1985 which leads to the suggestion that stock access to these areas is being reduced. At least

Table 8.1 The total area of plant communities on the Makatini flats in 1976 and 1985. The relative stocking density is an indication of the usefulness of pasture types to cattle (methods CHAPTER 4). Data for 1976 is from Furness (1981). Data for 1985 is from land surveys and subjective interpretation of aerial photographs. * Furness considered these species as one plant community.

PLANT COMMUNITY	AREA 1976 ha	AREA 1985 ha	INCREASE IN AREA %	RELATIVE STOCKING DENSITY %
Cynodon dactylon	171	443	160	34
Echinochloa pyramidalis	*1 096	827	-24	31
Cyperus fastigiatus	*1 278	208	-84	15
Phragmites	82	173	110	11
Floodplain fields	1 344	2 675	99	3
Floodplain forest/browse	534	149	-72	1
Floodplain sand flats	295	326	11	1
Off-floodplain forests	56 300	56 300	0	4
Total/All areas	61 100	61 100	0	100

85 % of the wooden fences along the floodplain edge (Figure 2.2, p.21) were constructed between 1984 and 1987 to prevent stock from using the floodplain during periods of crop growth (APPENDIX 1:3). Intensification of the use of fields and the construction of new fences are both linked to increases in the human population (a).

8.2.1.2 Disease (e; P)

In a system where there is little access to veterinary services a high level of animal health cannot be expected. At present the incidence of disease-related death and reported cattle illnesses is low and animals are mostly in good condition (CHAPTERS 2 and 4). Normal illnesses are not considered a major "threat" to the system although improved facilities would probably improve animal productivity (fecundity, milk production etc.).

The area has a history of epidemics (CHAPTER 2) and the possibility of infrequent but major stock losses caused by disease should not be ignored. Factors which contribute to this threat are the illegal immigration of people from Mozambique (a foot-and-mouth area) and the lack of adequate veterinary services to deal with epidemics (CHAPTER 2).

Two factors that are likely reduce disease resistance in cattle are a loss of condition (caused by overstocking) and cross-breeding of the native Nguni stock with European cattle breeds (Hundleby *et al.*, 1986). Cross-breeding was probably started in the early 1950's (Bonsma *et al.*, 1950) and there are now few pure bred Nguni in the area (Hundleby *et al.*, 1986).

8.2.1.3 Inefficient use of available plant and animal resources (e; P)

Reduced daily grazing time due to a lack of herd boys is a problem in KwaZulu generally (Tapson & Rose, 1984) and although not currently serious on the Makatini the problem may develop (CHAPTER 4). Herding requirements are linked to both agricultural expansion and overstocking and should not be viewed in isolation.

The small size of personal herds makes it difficult to manipulate herds to obtain the maximum benefit from different utilities. An example of this is the inefficient use of draught potential (CHAPTER 2).

8.2.2 Environmental threats

All external factors considered a threat are expected to cause a reduction in the quality or quantity of forage available in the area and result in overstocking. These factors are:

a) Reduced grazing land area caused by extension of irrigated lands (P).

b) Reduced grazing land area caused by game reserve expansion (p).

c) Reduced floodplain pasture quality and productivity caused by modification of river hydrology when water is allocated to expanding irrigated agriculture (P).

d) Reduced accessibility to floodplain pastures during the winter "stress period" (CHAPTER 4) because of modified river hydrology (p).

8.3 PERSPECTIVES ON SYSTEM MANAGEMENT

The two groups of people on the Makatini flats directly concerned with cattle management are cattle owners and regional developers. This section deals with the management perspectives of these groups and the management problems that arise as a result of their different perspectives.

8.3.1 The traditional pastoralist's perspective

The principal objective of Makatini cattle owners is to provide for immediate personal or family needs (CHAPTER 4). This means that they tend to manage grazing and animal resources using strategies which provide returns on a short time scale and at a local level (APPENDIX 1 and CHAPTER 2). Their perspective is narrow in that they have a poor understanding of the regional context of their activities and because they have no control over developments taking place at a regional level. The management system of Makatini cattle owners is summarised in Figure 8.2 .

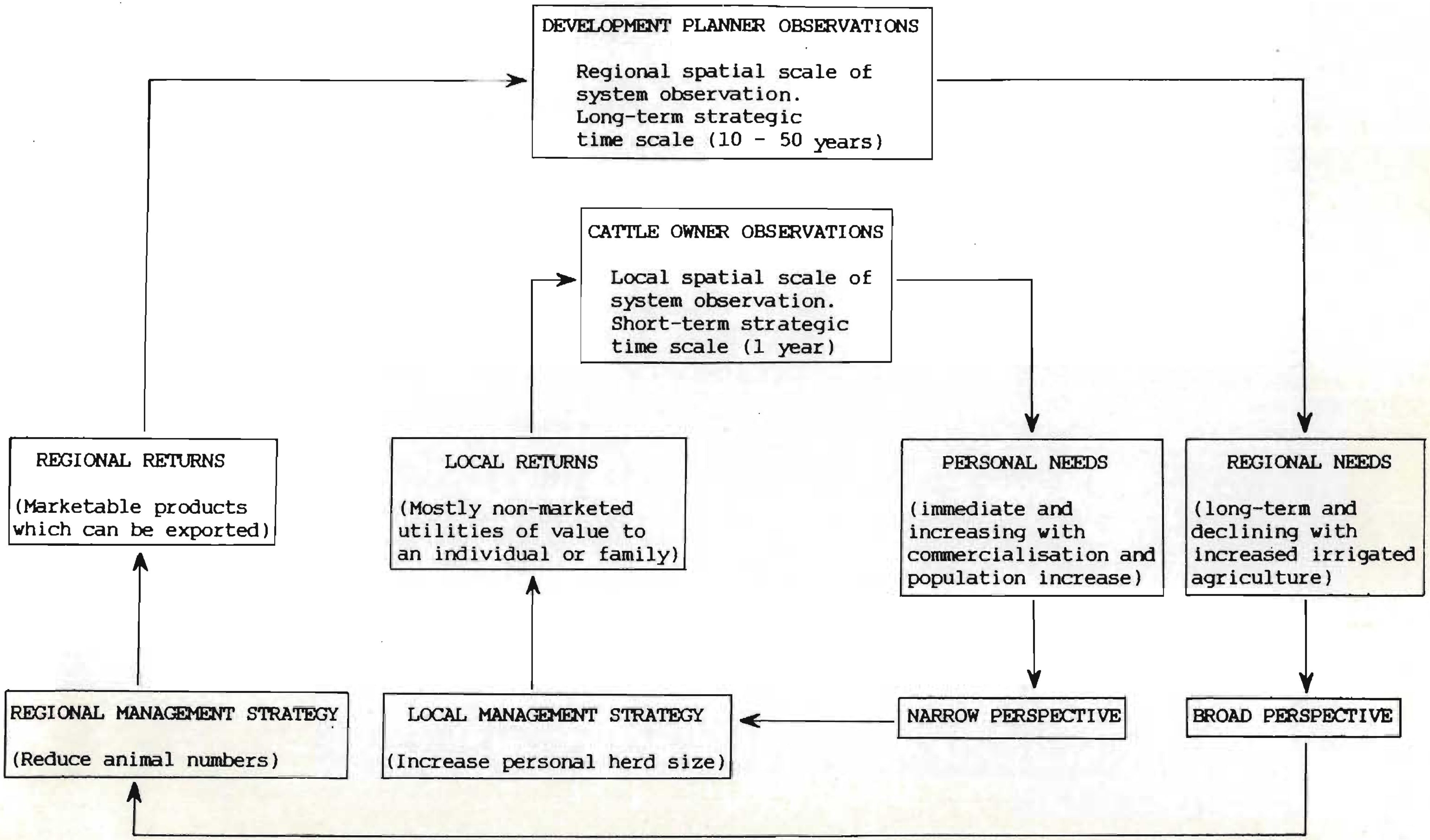

Figure 8.2 The management systems used by development planners and cattle owners on the Makatini flats.

Although the management strategy of Makatini cattle owners is still that used in traditional subsistence systems (Mentis, 1984), local people's needs have changed. Derman and Poultney (1987) describe the Makatini flats' economy as "consumer-based" and local people now recognise the need for schooling and formal employment (Derman & Poultney, 1987; CHAPTER 4). Living standards change as the socio-economy becomes more consumer oriented and this increases the demand for cash returns from local resources. Increases in human population also increase the overall needs of local people.

Cattle owners must attempt to cater for their increasing needs. However, because their perspective of opportunities is local (Derman & Poultney, in press) and operative on a short time scale (year to year; APPENDIX 1:3) their management strategy is to maximise immediate returns from livestock and this is best achieved by increasing animal numbers.

Cattle owners are long-term strategic planners in that they use cash returns from stock to invest in education and agricultural or other machinery (APPENDIX 1: 1.10). However, management of pastoral and animal resources is strategic only in the short-term. A cattle owner operates tactically on a short time scale because his needs are immediate and before he can be expected to participate in long-term strategic planning of cattle management, those needs must be met. This means that the introduction of a long-term cattle management strategy cannot depend on an initial reduction in cattle owners' returns.

Most important is the fact that the traditional pastoralist's perception of pastoral resource management must be expanded because he cannot be expected to think strategically in the long-term with his current, narrow/local perception of pastoral system management.

8.3.2 The regional development planner's perspective

The regional planner has a broad perspective of the livestock system which enables him to plan strategically in the long-term (10 - 50 years) and on large spatial scales (e.g. the Makatini flats). Needs and returns are identified on a regional level and management planning is oriented towards regional objectives (Figure 8.2).

Planning on a large scale usually conflicts with local perspectives, goals, and strategies. For example, overstocking can only be prevented in the study area in the long-term by a reduction in cattle numbers as agriculture expands (8.2.2, p.117), but proposals to reduce herd size conflict with local stock owners' management strategies (CHAPTERS 3 and 4).

Pastoral management planned solely on a regional scale would result in differences in the quality and quantity of forage available to animals in each of the pastoral zones in the study area (Figure 2.2, p.21 and Table 3.1, p.32) being ignored and thus management decisions concerning stocking density would be insensitive to local differences in overstocking problems.

The regional planner tends to identify only marketable utilities resulting in management planning biased toward the improvement of returns from that source (CHAPTER 5). For example, Uys *et al.* (1985) established that by altering the structure and market offtake from the regional herd in Maputaland, a three-fold increase in returns from cattle could be achieved without any increase in the numbers or condition of animals. However, they considered only the regional value of cattle (i.e. exported beef animals). Hearne and Buchan (in prep.) used similar techniques, but considered the value of animals to local stock owners. They predicted that the same alteration in herd structure and increase in offtake would not increase the value of returns to stock owners since it only meant that the draught value of oxen which had been removed from the herd would be substituted for market returns.

If management planning at a regional scale is to be effective and accepted by stock owners, planners must have some understanding of the value of all the utilities that cattle provide in the local context as well as of the objectives and strategies used by local people.

8.3.3 Identification of management options for the Makatini and other African pastoral systems

There are two aspects to the management of pastoral resources on the Makatini flats. Firstly, management is concerned with improving the efficiency of resource use or management at the local level. Secondly, at a regional level changes in the resource base, for example changes in the area of grazing land must be taken into account. Discussion of system structure (CHAPTERS 3 to 7) shows that there are many ways in which the returns from available vegetation could be improved. But, it appears that the most important threats to system maintenance (8.2, p.111) are probably environmental (external to the system). Regardless of how well pastoral resources on the Makatini are managed, external factors such as the expansion of the Mjindi irrigated agricultural scheme, increased regulation of the Pongolo River and increased human population are likely to continue to reduce the potential of the pastoral resource base (the vegetation of the Makatini flats and Pongolo floodplain). This means that management at the local level can only be expected to succeed if it is co-ordinated with regional development planning.

The question which arises is whether the changing social structure in the area (CHAPTER 2) will result in gradual destocking of the flats as agriculture expands and people move from a subsistence into a market-based economy. In other areas of KwaZulu, subsistence farmers have become commercial sugar-cane growers and many do not keep cattle, preferring to buy them or the utilities they provide when a specific need arises (Tapson & Rose, 1984). As people are incorporated into the Mjindi irrigation scheme or establish private commercial agricultural enterprises, they may reduce their cattle holdings. However, this does not appear to be happening as people that have generated capital through the Mjindi scheme commonly invest in cattle (Cloete, C., 1988, pers. comm., Department of Development Aid).

Despite the poor long-term prospects, investment in cattle on the Makatini is continuing because of the high returns from cattle ownership (CHAPTER 5). Tractors will probably become more readily available to commercial farmers on the Makatini. However, this will not necessarily reduce the utility value of cattle since cattle owners can change the composition of their herds and receive an equivalent return from the sale of ten, rather than the current three, percent of their cattle holdings annually (Uys *et al.*, 1985; CHAPTER 3). What is important is that it seems unlikely that cattle numbers will decline naturally as the social system on the Makatini becomes more commercially oriented. This means that overstocking can only be controlled by a much more formal management system than already exists and that intensification of the stocking system will be necessary. Any proposals for "cattle camps", pasture intensification or supplementary feeding will have to be made in conjunction with the area's more general development programme.

In the light of the importance of environmental factors in influencing returns from the Makatini pastoral system, it should be noted that the Makatini is fairly typical of traditional systems (CHAPTERS 1 to 6). The management on the small-scale of individual herds and on the basis of the short-term needs of cattle owners (CHAPTER 5) make "internalised" traditional systems like the Makatini highly susceptible to degradation when development (a change from a subsistence to a consumer-based economy) occurs. There are numerous examples of African pastoral development programmes which have failed because development planners perceived the system on a regional scale and did not take cognizance of local socio-economic needs and the pastoral management strategies adopted to fulfil those needs (Baker, 1980; Ayuko, 1981; Perrier & Craig, 1983; Deng, 1984; Boonzaier, 1987) and it is important that an attempt to prevent pastoral system degradation on the Makatini flats be made as soon as possible.

Other researchers have advocated orientation of management toward the objectives of the stock owners and stated that traditional pastoral management practices should be used. However, the deleterious effects that development programmes have had on pastoral systems in other parts of Africa (Kloos, 1982; Marty, 1983; Krummel *et al.*, 1986) show that traditional/local management strategies are inadequate because of the development that is occurring in rural areas of the Third World.

It appears that the only viable option is management based on close liaison between the different interest groups; regional planners at the organisational level, researchers at the technical level, and stock owners at the personal or private level, as proposed by Linstone (1984). Through liaison regional planners and traditional stock owners can improve their understanding of each other's perspectives, objectives and strategies and this combined "top down / bottom up" approach to management incorporating both short- and long-term objectives (Tapson & Rose, 1984; Frankenberger, 1986) should be possible in the context of Third World pastoralism systems.

8.4 RECOMMENDATIONS FOR MANAGEMENT

8.4.1 Management of the Makatini pastoral system

8.4.1.1 Liaison with local people

The objectives of management for the Makatini pastoral system, as defined in this study, are directly related to the aspirations of the cattle owners themselves and so the most important requirement for institutional management of the system is ongoing liaison with the cattle owners. Liaison is important because it can be used to broaden the perspective of cattle owners so that they can consider management on a larger spatial scale, such as communally owned grazing zones, and to plan management on a longer temporal scale. It can also help the development planner to understand the needs of stock owners and the value of the utilities cattle provide.

It is recommended that personnel who are able to act in the duel capacity of providing extension services and facilitating liaison between cattle owners and those involved in planning the development of the area be appointed.

Committees operating at the community level (e.g. dip tank committees) should be used as a link between cattle owners and regional planners and the formation of committees that deal with management at this level should be encouraged. It is suggested that the issue of overstocking be brought to the attention of cattle owners by extension staff and the committees encouraged to discuss ways of approaching the problem. Extension staff should act as catalysts in this respect and should be able to provide suggestions and examples of how the problem has been addressed in other areas (e.g. local taxation of pasture use or the establishment of local "cattle banks"; CHAPTER 3).

The establishment of pasture camps should be suggested to cattle owners and local inhabitants, but it must be emphasised that the establishment of camps should in no way be prescribed at the institutional level. If cattle camps are to be established, their size, location and management should be decided upon by the stock owners who will use them and by the local people who might be affected by the fencing of the land. Institutional input should be to provide advice only and to facilitate implementation of management decisions made by the local people.

There are three main advantages of proclaiming cattle camps:

a) They reduce the need for herding, which frees more children for school attendance and should reduce crop damage by cattle.

b) If well managed it may become acceptable to leave cattle in camps overnight, reducing the amount of time cattle spend moving to pastures each day, thus increasing the time available for grazing.

c) They provide a defined area which is used by a specific group of people and should provide a basis for tackling the overstocking dilemma associated with the "tragedy of the commons" problem. For example the number of animals using the camps could be controlled by charging a fee for the use of the camp and the proceeds could go to improve or develop the infrastructure associated with the livestock system.

8.4.1.2 Co-ordination with regional development strategy

Because of the close links between the livestock system and other aspects of the local socio-economy (for example agricultural production), changes to the stocking system should not be planned separately from the general development policy for the area. Any decision to develop new agricultural lands will reduce the pastoral resource base and, therefore, the potential of the livestock system to provide utilities. As long as the expansion of agriculture is made a priority by local people and developers there will be an ongoing need to reduce animal numbers in the area.

Discussion of regional development planning is beyond the scope of this thesis, but when land is annexed for irrigated agricultural development or game reserves, planners should assess the significance of the loss of grazing resources in terms of the utilities identified in CHAPTER 5 and compensate local people accordingly. It is most important to realise that the loss of grazing results in a loss of assets which provide a renewable source of utilities and are worth much more than the market value of the cattle.
It is unlikely that stock will be removed from the area and, therefore, it is important that an attempt be made to formalise the pastoral system so that stock owners use designated grazing areas or camps (8.4.1.1).

Because of the erodability and relatively low forage production potential of off-floodplain areas with sandy soils (CHAPTER 1) and the suitability of other off-floodplain areas for agriculture, the best locality for any pasture intensification is on the floodplain. Irrigation of *C. dactylon* pastures should be considered, although this may not be economically practical and would have to be carefully controlled to prevent erosion. Cooperative management of *E. pyramidalis* vegetation could also be used to ensure that this vegetation is fully utilised and that this forage remains acceptably dry for most of the year.

8.4.1.3 Use of floodplain vegetation

In view of the seasonal importance of floodplain vegetation to cattle (CHAPTER 6) it is recommended that provision be made for continued access to these areas, at least in winter. To maintain forage production it is important that provision be made in the operating rules for the Pongolapoort dam, for the release of at least one flood each summer.

If access to the floodplain by cattle is to continue it will also be necessary to encourage the formation of new fields in dry-land areas surrounding the floodplain rather than on it. It is suggested that the development of small-scale irrigated agriculture off the floodplain using water pumped from the river be encouraged to prevent further development of subsistence agriculture on the floodplain. Most important is that expansion of subsistence fields into *E. pyramidalis* vegetation should be discouraged.

8.4.1.4 Reduction in the need for draught animals

If tractors were more easily accessible to the people on the Makatini it would probably help reduce the problems associated with the overstocking. With access to tractors the need for draught animals would be eliminated and herd structure could be adjusted to improve the output of other utilities such as milk and market animals. Smaller herds would be able to supply these utilities and the need to increase herd size to improve agricultural production through the use of an animal-drawn plough would be eliminated.

8.4.1.5 Cattle breeding

Since the area has regional importance as a source of pure breeding Nguni stock, local people should be encouraged to breed Nguni stock rather than introducing European breeds. Cattle owners should be made aware of the value of pure breeding Nguni stock and that Nguni animals are more disease resistant than the European stock that is being introduced.

8.4.2 Management of traditional African pastoral systems

The extent to which the findings of this study apply to the management of other systems depends on the similarities between the structure of the Makatini pastoral system and that of the other areas in question. Socio-economic conditions may change over short distances and general assumptions about the motivations behind local stocking practices should not be made. However, the structure of the Makatini system is in many ways typical of traditional African pastoral systems and some issues which require special consideration in planning the management of these systems have been identified and are listed below:

a) The effective management of traditional pastoral systems must be based on an understanding of the objectives of local people and must be directed toward the realisation of their objectives and not toward those of institutions or government departments.

b) An assessment of the economic value of stock to their owners within the local socio-economic context is needed before plans to change the system of management are considered.

c) The livestock in a traditional/subsistence-based economy should not be considered as a separate industry that can be managed and manipulated independently from other activities. The development or management of the pastoral system should be planned in association with the planning of agricultural and other forms of development for an area, and the links between pastoralism and other aspects of the socio-economy must be understood before proposals are made.

d) The dynamics of vegetation use should be understood on a range of spatial and temporal scales. The importance of different vegetation types and pasture areas should be assessed on a daily and seasonal basis to determine where the important grazing resources are and when they are used. Planners must be able to assess the significance of specific pasture areas to the system on the time scales over which the continued provision of utilities is envisaged.

e) Where the stock have access to wetland pastures special consideration should be given to determining the importance of these areas and the circumstances surrounding their use, including how the hydrology of the system restricts access and the rationale for the patterns of use adopted by local stock owners.

f) Institutional or state involvement in the management of traditional pastoral systems should be restricted to the provision of extension services and advice about stocking problems and the prescription of general schemes to "improve productivity" should be avoided, except in as far as they assist in the attainment of local people's management objectives. Institutional involvement in management planning should be based on continual liaison between the regional planners and local people. The formation of local stock management committees to facilitate this liaison is recommended. Extension officers trained specifically in the problems associated with subsistence pastoral systems, and who can act as a link between regional planners and stock owners, are important to the success of any Third World pastoral system development programme.

8.5 RESEARCH RECOMMENDATIONS

Pastoral systems are complex ecosystems (McNaughton, 1985) because they necessitate consideration of a large number of interacting components (e.g. rainfall, pastures, cattle and man; CHAPTERS 3 - 7) and a framework for their description is required. Ecosystem management almost invariably involves characterisation and prediction of the behaviour of complex systems (Gerritsen & Patten, 1985) and traditional pastoral systems, such as the one discussed in preceding Chapters, are no exception. Collation of large amounts of information relevant to management decisions for such systems is difficult, and if done intuitively the manager may not make full use all available information. Two characteristics of ecosystem structure which make collation of information, and consequently prediction of system behaviour, particularly difficult are the connectivity of ecosystems (linkages between components) and their dynamic nature (Barret & Rosenberg, 1981; Higashi & Patten, 1986).

8.5.1 The Makatini pastoral system

Simulation and optimisation models are management tools that can be used to incorporate consideration of system connectivity and dynamics into decision-analysis and they allow information that has been collected at several different observational levels (e.g. seasonal and yearly) to be incorporated into predictions about changes in the system as a whole.

A simulation model which could be used as a decision-analysis aid for the management of the Makatini pastoral system and which incorporates most of the information presented in the preceding Chapters has been developed (Hearne & Buchan, in prep.). The discussion of the structure and use of this model is beyond the scope of this thesis but what is suggested here, is that the model be used to collate information about the Makatini pastoral system.

No analysis has been made of the long-term effects of grazing on any of the vegetation types in the study area, or the extent to which the forage production capability of vegetation is being reduced by high stocking densities. As most grazing occurs in the dry-land areas surrounding the floodplain it is recommended that investigation of the animal/plant interactions in these areas be given priority. Emphasis should be placed on investigation of the sand forest areas which have a poor soil structure (CHAPTER 1) and are, therefore, probably the most susceptible to degradation through overstocking.

The model of the pastoral system (Hearne & Buchan, in prep.) has not been calibrated and it is suggested that the use of the model as a management tool be researched further. The system should be monitored and the model calibrated against the changes which occur. Information about the interaction between forage production and grazing in off-floodplain vegetation should be incorporated into the model and the model refined as more information about the interaction between stock and vegetation becomes available. The pastoral model could also be linked to the existing hydrological model of the Pongolo floodplain (Alexander & Roberts, in press) so that more accurate predictions about how the release of water from the Pongolapoort dam influences the value of utilities received by stock owners can be made.

In view of the importance of milk as a utility, more detailed information about milk yields and the value of milk to local people is needed and ways of improving yields of local cattle should be sought.

8.5.2 African pastoral systems

Management of complex African pastoral ecosystems requires the backing of a research programme which is geared toward collation of information in a problem-oriented framework which includes the principles of system ecology i.e. the interdependence of different system components and the dynamic nature of systems (Norton & Walker, 1985; Higashi & Patten, 1986). Information about these complex systems which may have been observed on several different spatial and temporal scales must be collated.

Simulation or optimisation modelling has been recommended for rangeland management (Scifres, 1987) and where used in Africa, the models have produced good results. From the preceding Chapters of this thesis it appears that there is a need for economically oriented simulation models of African pastoral systems which include consideration of the full range of marketed and non-marketed benefits received by stock owners. The models could be used to simulate the complex interaction between forage production in different vegetation types and the production of utilities by stock. The value of such models is that the information used to make predictions about system state and functioning is quantified and can be continually added to or modified without loss of the existing concepts. Further, through the use of models, all available information on the system's dynamics and the simultaneous effects of different forcing functions can be accounted for in a single framework. It is recommended that existing simulation models, particularly those that have an economic objective function, be adapted and more generally applied in the management of traditional African pastoral systems and that construction of new models that can be used as pastoral system management tools be considered.

Although this study has provided some insight into why overstocking problems occur on the Makatini and other traditional pastoral systems, the question of how to prevent overstocking problems has not been solved and this issue should remain a research priority for rural development institutions and government agricultural departments throughout Africa. In particular, sociological investigation aimed at identifying ways to reconcile the interests of traditional or subsistence pastoralists with those of regional developers is the most important need identified by this research.

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APPENDIX 1

The interview schedule used to assess the attitudes of Makatini stock owners. N = 20; 2 % of owners (Belson, 1981).

Questions were phrased so as not to be leading. Because of this, and the need to use several simple questions to cover one issue, frequent *ad hoc* changes to the question list were necessary. Questions listed are a summary of the points covered.

1 Perception of stock utility value

1.1 Why do you keep cattle ?

This question was not taken seriously by 80 % of respondents as they felt that the benefits were obvious. The remaining 20 % stated that cattle had many values and named milk as the most important. Attempts to get respondents to give an importance rank to known uses were unsuccessful since all found it difficult to separate one use from another.

1.2 What proportion of cows can be milked after calving down ?

Thirty percent of respondents said that all cows were milked. Seventy percent said that as many as possible were milked but that some cows (about 20 %) could not be milked. Twenty five percent attribute the failure to milk to the lack of grazing in winter and 45 % attribute it to mastitis. One owner said that his ability to milk all his stock resulted from his successful breeding programme for milk production.

1.3 Do you sell cattle ?

All respondents had sold cattle and said they would sell again if the need arose. Seventy five percent gave cash needs as the reason for selling cattle. Specific reasons given were; school fees 10 % , irrigation pumps 10 % and food 10 % (refer to question 1.10).

1.4 Do you slaughter cattle ?

All respondents slaughtered cattle but 90 % killed only sick or old animals that were going to die.

1.5 Do you have a draught team ?

Six respondents (30 %) did not have a team. Of these, five had less than 13 cattle and one had twenty cattle but said his oxen were too young to use. The 70 % with teams all had more than 15 cattle. Those with more than four oxen used extras as substitutes for tired oxen, or used them in additional teams.

1.6 What jobs do your draught animals do ?

Thirty eight percent of owners with a draught team used their animals only for ploughing. Twenty four percent said ploughing was the main use but that they also used animals for transporting water, harvested crops, old people or building materials. Thirty eight percent said teams were used for ploughing only, but with prompting, added that they were also used for transporting various heavy items.

1.7 How often do your draught animals work ?

Half of the respondents stated that use was dependent on how good grazing was as this determined animal condition (see question 3.2). Thirty eight percent of team owners ploughed on six days a week, 38 % on five days a week and 24 % on four days a week. Two respondents said their activities were irregular; one because he had occasional access to a tractor and the other because he was busy with the building of a store. All owners used teams regularly on their own fields between August and December but said that the demand for ploughing declined later in the season. Sixty three percent of respondents did some ploughing between January and July, either to plant crops after late rains or to plant winter crops on the low-lying floodplain areas or irrigated fields.

1.8 Do your draught animals plough other people's fields ?

Half of the respondents' teams were used on fields other than their own, but all stated that this was done only after their own ploughing had been completed. Seventy percent stated that friends' fields were ploughed. In these cases no cash payment was made. Of all draught team owners only 25 % hired out their teams and for this they asked a fee of between R 6.00 and R 8.00/team/day. Respondents that did not hire out teams were reluctant to state a fair price as they considered the conditions of individual transactions to be highly variable.

1.9 Are cattle required as part of a marriage contract ?

All respondents were married and felt that cattle were an important part of a marriage contract. Depending on the "quality" of the bride, between four and sixteen cattle were considered necessary for *lobolo*.

1.10 How do you intend to use your stock in the future ?

All respondents would like to increase their stock holdings but 30 % said that they were planning to sell stock to make a specific purchase such as irrigation pumps (15 %) furniture (5 %) or a vehicle (10 %) (see question 1.3). Those planning to buy machines all had 18 or more cattle.

2 Pastoral interaction with agriculture and migrancy

2.1 Do you or the herd boys decide where stock should graze ?

All respondents directed herd boys to specific pastures.

2.2 Do you have fields on or off the floodplain ?

All respondents had some fields in both areas.

2.3 Is crop damage by stock a serious problem ?

Twenty percent of owners felt crop damage was unimportant because it was effectively prevented by herding and fencing. Twenty percent of respondents considered losses to be minor and 60 % said crop damage was a serious problem. Thirty percent of respondents pointed out the importance of fences in protecting fields and 35 % said careful herding was needed to prevent damage.

2.4 Where and when does crop damage occur ?

All respondents who considered crop damage a problem said the problem was most critical on the floodplain. Twenty five percent of these said damage occurs only in summer, the season when most crops are grown. Thirty percent said the problem occurred all year round and 45 % said that problems occurred primarily in winter. The last group all attributed the seasonality of the problem to a lack of off-floodplain grazing in winter.

2.5 Are floodplain pastures important for grazing and does agriculture restrict access to these or any other pastures ?

Seventy percent of respondents said floodplain pastures had special importance and all of these attributed this to the provision of winter grazing when off-floodplain forage was scarce. Twenty percent felt that the floodplain area available was too small to have particular value, although it would be more valuable if it were larger. Ten percent thought floodplain grazing had no special value.

Seventy percent of owners felt agriculture restricted access to pastures and all of these said floodplain pastures would be used more if existing restrictions did not apply. However, only 40 % of respondents considered floodplain grazing superior and 60 % preferred to use off-floodplain pastures whenever possible. The desire to increase floodplain use arose because of the shortage of off-floodplain forage and not because it was considered better grazing.

2.6 Why is there a conflict between pastoralism and agriculture ?

Sixty five percent of respondents who perceived a conflict, attributed the problem to a lack of space. None of these thought individual stock owners possessed too many cattle. They saw the increasing human population with associated increases in stock numbers and floodplain field area as the cause of conflict. Fifteen percent attributed the problem to bad fencing and 20 % attributed a lack of herd boys because most children attended school.

Most answers to this question were complex. The quantitative analysis does not give a true reflection of the importance attributed to the lack of responsible herders over ten years old, or the need for better fencing (see question 2.3).

2.7 How can the problem of crop damage be overcome ?

Eighty five percent of respondents stated that people in the area are making a joint effort to build fences along the edge of the floodplain to exclude cattle. Fifty percent said that stock owners pay fines if their cattle damage other people's crops.

3 Perceptions of management

3.1 What changes would benefit you most as a stock owner ?

Twenty percent of respondents were not prepared to answer or were unsure of this but others gave several answers. Respondents did not answer specifically in the role of "stock owners", tending rather to discuss their agricultural problems.

Of those who gave answers, 61 % said a fence was needed along the floodplain's edge. A further 23 % mentioned fencing in general, one proposing grazing camps where herding would be unnecessary. Forty six percent mentioned a need for water points away from the floodplain so that stock would be able to make use of palm veld pastures to the East of the sand forest (Figure 1.6, p.13).

Forty six percent said that sales yards are too far away. All these owners lived more than 25 km from the nearest market (Figure 1.6, p.13). Thirty one percent of respondents said that oxen could not satisfy the demand for ploughing and that tractors were needed. Twenty three percent mentioned a shortage of dip tanks. Fifteen percent requested hippopotamus eradication, although this was because of crop damage rather than competition for forage. One respondent said there were frequent forage shortages and that the proposed extension of game reserves would severely aggravate this problem. Only one stock owner requested better veterinary advice.

3.2 What are the most important problems stock owners face ?

Sixty percent of respondents felt this question could only be addressed through meetings because of the diversity of owner interests. This diversity was attributed to the differing proximity of owner homesteads and fields in relation to utilities such as pastures, water points, dips and sales yards. Most respondents reiterated their responses to question 3.1, but 25 % said stock loss or weakness of oxen during drought was a problem. This was always attributed to lack of pastures.

3.3 Are the pasture shortages worse now than they were many years ago ?

Seventy percent of respondents said pastures were more difficult to find than they had been in the past. The other 30 % were unsure.

3.4 Why is it more difficult to find good grazing than it used to be ?

All respondents attributed the lack of pastures to a reduction in the space available to them. Twenty percent stated that the expansion of game reserves had caused the problem. Sixty five percent considered the expansion of agriculture on the floodplain to be the cause of the problem (see question 2.6). Forty five percent explained that there were now many more people in the area. The latter group all expressed their answers in terms of the human population rather than stock numbers.

3.5 What medication is given to your cattle ?

All respondents dipped their cattle and said that vaccinations against rabies and other diseases were occasionally conducted by KwaZulu officials. Sixty percent said that they purchased their own medicines, but all stated that medicines were difficult to obtain and were often prohibitively expensive. Thirty five percent mentioned that they were trying to establish small, communally owned veterinary dispensaries so that they could co-operate in the purchase of medicines.

4 <u>Use of floodplain vegetation</u>

For comment on preferences for floodplain and dry-land areas refer to question 2.5 .

4.1 Which floodplain vegetation types provide the best grazing ?

This question was complicated by the fact that the accessibility of different vegetation types varied depending on the locality of a respondent's homestead. Forty percent of respondents said there was little difference between the qualities of different floodplain vegetation types. Sixty percent said that *E. pyramidalis* was only acceptable in winter when it was dry as it caused scouring if grazed when wet. Twenty percent said they preferred to use *C. dactylon* to other vegetation and 10 % said *Phragmites* is the most acceptable forage type.

APPENDIX 2

Milk production data used to determine the number animals needed to provide given quantities of milk (CHAPTER 3) and the utility value of milk (CHAPTER 5) (methods CHAPTER 5).

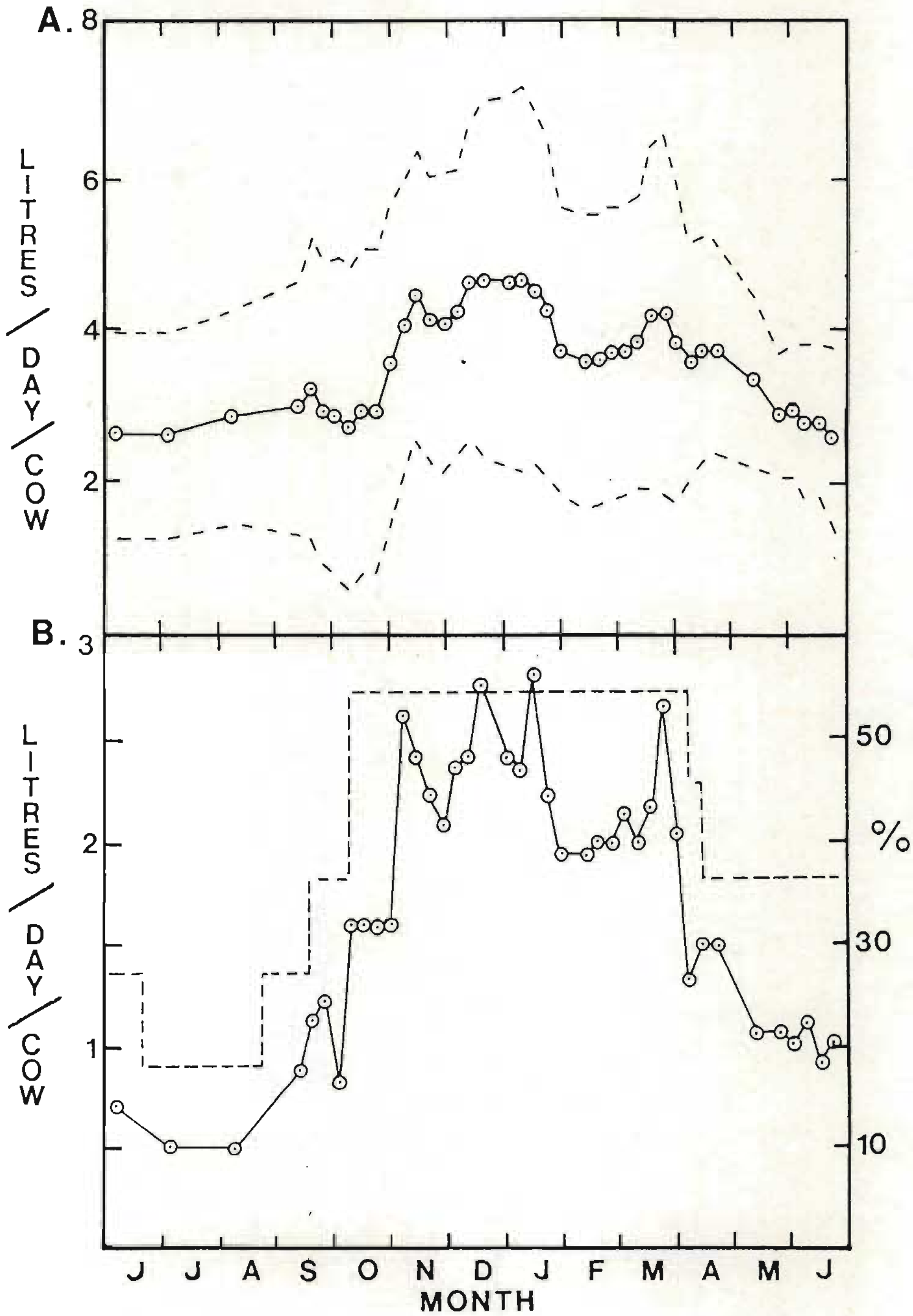


Figure A2.1 A. The milk yields of lactating cows on the Makatini flats, ——, (1985 - 1986). - - - = 2x s.e. (N = 15 cows).
B. The percentage of cows that are milked daily, - - -, and the mean milk yield from all cows in the herd including those not lactating, ——, (N = 15 cows).

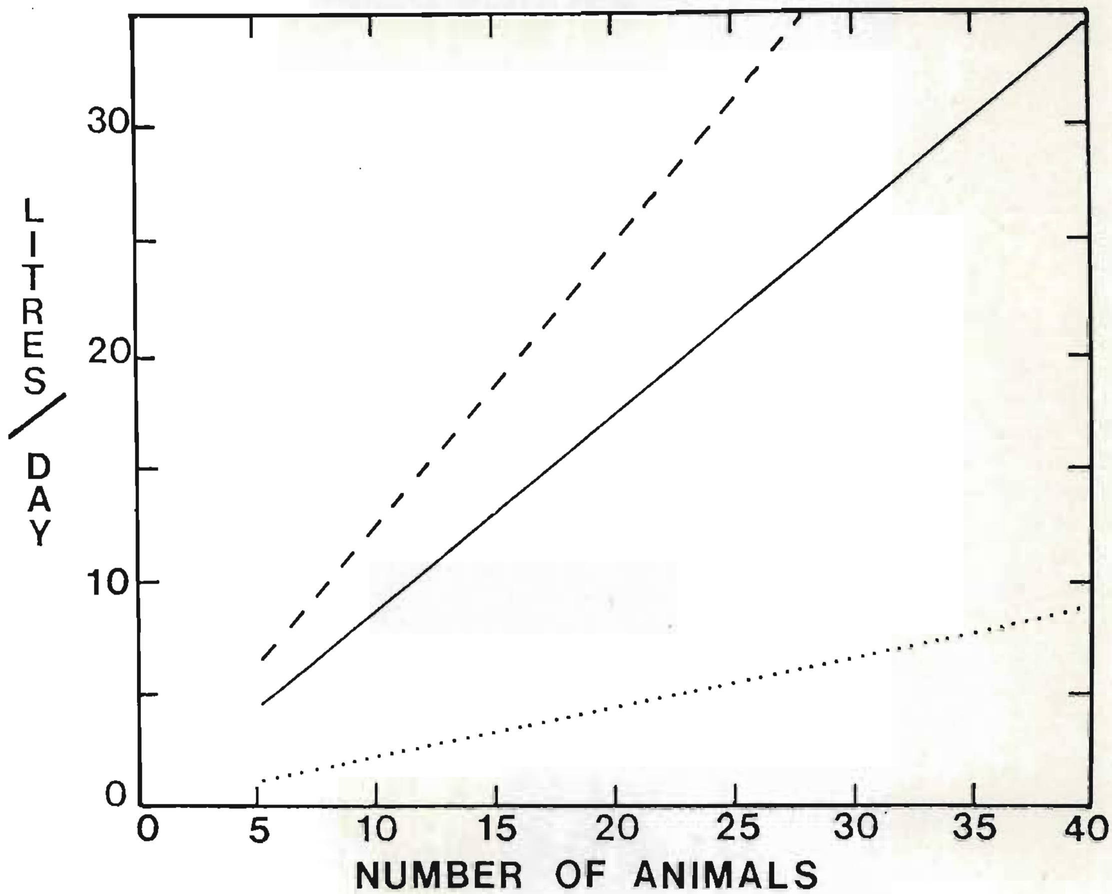


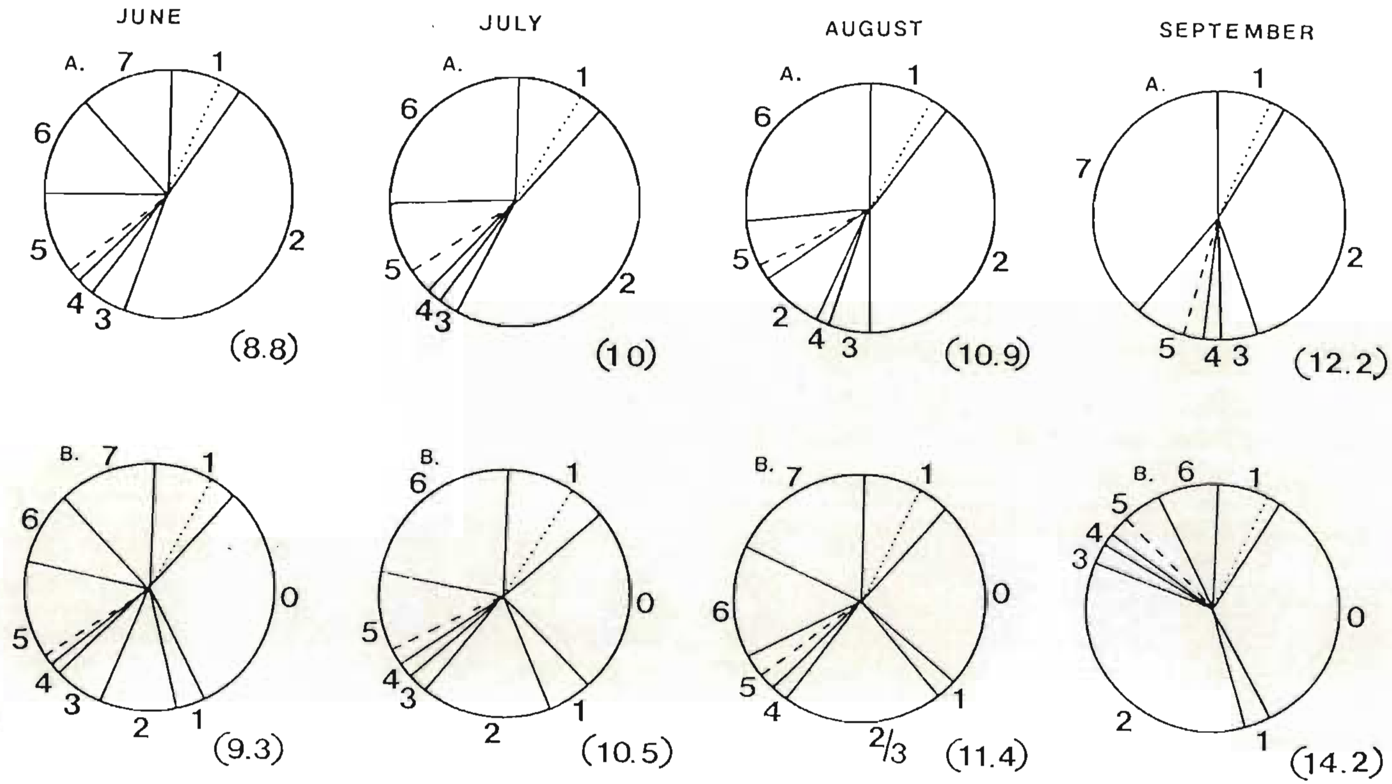
Figure A2.2 The Maximum, - - -, Mean, ---- and Minimum, ·····, daily milk yield received by Makatini cattle owners as a function of the size of their herd. Yields approaching the maximum are received in December - January when most cows are lactating and yields/cow/day are high (Figure A2.1) and minimum yields are received in July - August. The herd composition determined in CHAPTER 3 is assumed.

APPENDIX 3

Examples of the data taken during activity budget determination (CHAPTER 6; Figure 6.5, p.83).

Table A3.1 The activity budget data collected in June 1985 for one of the herds monitored (methods CHAPTER 6). A, B and C are sub-groups of animals engaged in different activities to animals in the other sub-groups.

TIME OF DAY	NUMBER OF ANIMALS	LOCALITY OF ANIMALS	ACTIVITY
6.45	22	Homestead in pens	Resting
7.00	22	Moving to pastures	Walking
8.00	(A) = 18 (B) = 4	*E. pyramidalis* stands Floodplain fields	Grazing Ploughing
9.15	(A) = 18	*Phragmites* vegetation	Grazing
9.45	(A) = 18	Fallow floodplain fields	Grazing
10.00	(A) = 18	*E. pyramidalis* stands	Grazing
10.30	(B) = 4	Floodplain	Moving
11.00	(A) = 18	Sweet potato fields	Grazing
12.00	22	*E. pyramidalis* stands	Grazing
13.00	22	Floodplain to homestead	Walking
14.00	(A) = 3 (B) = 6 (C) = 14	At the homestead At the homestead At the homestead	Being milked Grazing Chewing the cud
15.00	22	Home to dry-land fields	Walking
15.15	22	Dry-land fields	Grazing
16.15	22	Dry-land fields to home	Walking
17.00	22	Homestead	Resting and chewing the cud
18.00	22	In pens at homestead	



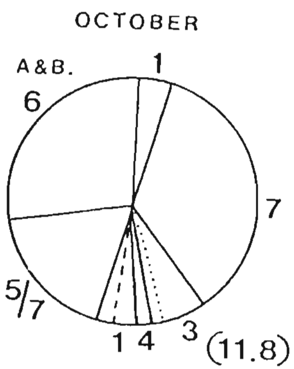


Figure A3.1 The time spent by a herd of 22 cattle engaged in different activities during one day of each month in 1986. In months not indicated the herd did not graze on the floodplain. A = the main herd and B = the draught team of four animals. Numbers in brackets are the total number of hours animals were active. 0 = ploughing. 1 = moving to grazing or ploughing area. 2 = grazing. 3 = moving to a water point / pan. 4 = drinking. 5 = moving to homestead. 6 = resting at homestead and milking. 7 = grazing off the floodplain. ····· = movement onto the floodplain. - - - = movement off the floodplain.

APPENDIX 4

Data on cattle marketing and the death of cattle in different age/sex classes.

Table A4.1 The proportion of total cattle holdings sold and market values of cattle from seven different age/sex classes. Data for northern Maputaland sales yards, 1985/1986. A = all stock. P = stock with a condition score of 3.5 or less on a scale of 1 - 10 (van Niekerk & Louw, 1980). B = bull, C = cow, O = ox. 1 = < 1 year, 2 = 1 - 2.5 years, 3 = > 2.5 years.

Category	B1		B2		B3		C1		C2		C3		O	
Sample	A	P	A	P	A	P	A	P	A	P	A	P	A	P
Proportion of stock sold	0.082		0.108		0.152		0.015		0.047		0.242		0.354	
Mean price (Rand)	191	154	238	70	384	264	224	114	300	228	325	258	392	283
2 x s.e.	8	0	7	-	9	21	33	48	16	28	7	22	8	28
N	130	5	171	1	241	21	24	5	75	4	383	29	560	29

Table A4.2 Cattle death rates (proportion/year) for seven age/sex classes. B = bull, C = cow, O = ox. 1 = < 1 year, 2 = 1 - 2.5 years, 3 = > 2.5 years. Modified from Uys *et al.* (1985).

CLASS	B1	B2	B3	C1	C2	C3	O
PROPORTION	12.2	7.3	9.8	12.2	7.3	9.8	9.8

APPENDIX 5

The areas of different vegetation types (CHAPTER 6) in each of the grazing "zones" (Figure 2.2, p.21) in the study area. Values were calculated using land surveys and planimetry on aerial photographs. WET = conditions one month after flood (May 1985); DRY = conditions ten months after a flood (February 1986). Vegetation type: 1 = *Cynodon dactylon*; 2 = *Echinochloa pyramidalis*; 3 = *Cyperus fastigiatus*; 4 = *Phragmites* spp.; 5 = Agriculturally disturbed areas; 6 = Forest/browse; 7 = Sand flats; 8 = Open water (vegetation submerged).

VEGETATION TYPE

ZONE	1	2	3	4	5	6	7	8	TOTAL
				WET CONDITIONS: AREAS (ha)					
1	12.9	0.7	36.2	4.5	90.9	9.3	0.4	23.0	177.0
2	86.5	8.2	5.2	20.5	223.9	0.0	2.2	18.1	365.1
3	79.0	173.4	46.6	60.7	532.1	27.4	16.7	181.5	1 111.1
4	71.7	25.4	0.9	17.5	319.3	0.1	0.0	390.0	870.2
5	203.1	1.6	46.9	33.1	396.6	13.0	7.5	136.3	839.0
6	60.7	0.0	0.0	1.0	117.4	0.0	0.0	88.4	267.6
7	108.0	54.2	21.9	41.5	208.1	3.7	0.0	63.1	500.6
8	29.9	82.9	15.6	10.9	220.1	0.0	0.0	95.2	454.3
9	96.0	0.0	10.9	0.9	247.8	0.0	0.0	68.3	432.8
10	57.2	124.0	102.4	24.4	291.2	74.1	13.7	126.7	813.7
11	59.2	40.1	19.2	28.9	211.2	47.3	0.9	127.0	533.7
12	173.9	0.0	139.6	41.4	740.1	0.0	0.0	17.4	1 112.4
Total	1 038.1	510.5	445.4	285.3	3 598.7	183.7	41.4	1 335.0	7 478.3
				DRY CONDITIONS: AREAS (ha)					
1	22.3	0.8	36.2	4.5	90.9	9.3	0.4	9.7	177.8
2	102.8	8.8	5.2	20.5	223.9	0.0	2.2	1.9	365.1
3	104.4	220.3	84.7	61.1	525.3	27.5	20.8	69.5	1 111.1
4	150.4	37.2	5.8	17.5	324.8	0.1	7.8	281.3	870.2
5	307.1	2.9	62.6	33.1	397.9	13.0	7.5	150.0	839.0
6	110.2	0.0	0.5	1.0	117.4	0.0	0.0	38.6	267.6
7	124.3	73.1	29.4	41.5	208.1	3.7	0.0	17.4	500.6
8	53.6	111.6	21.8	10.9	220.1	0.0	0.0	36.5	454.3
9	116.2	0.0	23.1	0.9	273.1	0.0	0.0	10.6	432.8
10	80.4	154.8	113.7	25.0	291.2	74.1	19.4	54.2	813.7
11	68.7	59.5	24.0	43.7	211.2	47.3	3.9	75.8	533.7
12	190.1	0.0	139.6	41.4	740.1	0.0	0.0	1.5	1 112.4
Total	1 430.5	669.0	546.6	301.9	3 624.0	183.8	62.0	747.0	7 478.3