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# DRY SEASON FORAGING PREFERENCES OF CATTLE AND SHEEP IN A COMMUNAL AREA OF SOUTH AFRICA

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**Abstract**

We examined landscape and habitat (vegetation) scale foraging of cattle and sheep at two communal villages to determine the key resources utilised during the dry season. At a landscape scale, cattle at both sites displayed overall preference for the arable lands at this time although this diminished steadily as the dry season progressed. In contrast, sheep made considerably less use of these areas, showing only sporadic preference. At the vegetation scale cattle demonstrated greatest preference for crop residues and uncultivated 'commonage' areas although foraging in grassland increased considerably in the latter stages of the dry season. Sheep utilised a much smaller range of vegetation types, preferring crop residues and fields that had been recently fallow and avoiding all other vegetation categories. We suggest that given the spatial limitations in planned, communal villages, the arable lands function as key resource areas for livestock during the dry season. It is recommended that management of these areas emphasise greater integration of sheep and cattle grazing and focus on maintaining vegetation heterogeneity in order to facilitate opportunistic 'switching' in foraging patterns at different stages of the dry season.

**Keywords:** Grazing preference; heterogeneity; key resource; livestock; rangeland.

## Introduction

In many parts of Africa, opportunistic movement of livestock between different habitat types is a vital part of communal production strategies in dryland areas. Such movements may occur over extensive areas and often in response to seasonal fluctuations in the quantity and quality of available forage, or drought episodes (Scoones, 1992, Niamer-Fuller 1999, Turner and Hiernaux 2002). They are of fundamental importance in allowing animals access to spatially and temporally variable forage resources, particularly during the dry season. Indeed, there is now considerable evidence to suggest that the availability of 'key resource' forage areas during the dry season acts as a critical limiting factor on the numbers of livestock that can be maintained within drylands environments (Illius and O'Connor 1999 and 2000). In Zimbabwe, Scoones (1992 and 1995) has demonstrated the importance of opportunistic movement in allowing cattle to exploit resource heterogeneity, particularly key forage areas during the dry season. However, such extensive opportunism is not always possible in drylands environments where forage resources are spatially limited.

In South Africa, the ability of livestock owners to engage in opportunistic management strategies is severely restricted by the limited grazing land available in many communal areas and its division by boundaries that have little, if any, utility from a grazing ecology perspective. This is largely a result of the historical legacy of intensive state planning under minority rule, which both severely restricted the areas within South Africa in which black people could live (the homelands[1]) and forcibly relocated people into these areas during the apartheid era. Another important aspect of this was the centralised planning of grazing resources through the betterment schemes introduced throughout the former homeland areas from the late 1930s onwards. In the former homeland of Ciskei, the introduction of these schemes was particularly thorough, such that by the early 1970s nearly 80% of locations were subject to some level of betterment (Trollope and Coetzee 1975). Amongst other production-oriented goals betterment sought to formalise land use at the village level by dividing it into areas for residential use, arable crop production and livestock grazing through the use of fencing (De Wet 1987). This fundamentally changed the way in which grazing was managed from systems based largely on extensive communal grazing to those in which grazing resources were sub-divided between villages. The division of rangeland into camps also facilitated the onset of rotational resting and grazing, often under the centralised control of the Bantu Affairs Commission (Trollope and Coetzee 1975).

With a few notable exceptions these betterment schemes have been largely unable to accommodate the opportunistic strategies which give livestock access to key grazing resources during periods of forage limitation (Cousins 1993 & 1996). Indeed, as a consequence of the systematic imposition of betterment planning in the former Ciskei, many communities in the region now have only relatively limited areas over which their livestock can forage without transgressing community boundaries and risking

[1] This refers to the 13% of land set aside in 1913 as 'Bantustans' or native reserve areas exclusively for occupation by the different black tribes of South Africa. These were formalised and granted autonomy as separate homelands during the 1970s and 80s.

theft or impoundment. Such spatial limitations are particularly problematic in areas where the forage shows a marked seasonal decline as without the provision of supplementary feed livestock (particularly sheep) lose body condition and may die.

In this environment of permanent settlement, with limited forage opportunities both spatially and in many cases, temporally, decisions concerning intra-landscape plant community access by animals become more critical than in transhumance systems to prevent overuse of the forage supply (Stuth *et al*. 1993). Thus, from a grazing management perspective it is of particular importance under these more static landscape conditions to understand forage selection by livestock at the plant community level within key resource areas (landscapes) that livestock exploit. The degree to which these choices are made by livestock or their owners is also of importance, as the use of key forage resources by livestock is often driven by decisions made at the herder rather than the animal level. In the communal grazing systems of the former Ciskei, the arable land allocations function in this key resource role. Historically, this was limited largely to the use of the crop residues from these areas during the dry season. However, in the central Eastern Cape region of South Africa there has been a significant decline in crop production in communal areas in recent decades (Eckert and Williams 1995). This means that crop residues now form only a relatively small part of a mosaic of vegetation at varying stages of succession found on the arable land allocations (Bennett 2002). Whilst the value of crop residues as a feed source for livestock during the dry season has been well documented in many areas of dryland Africa (De Leeuw 1997, Gertenbach *et al*. 1998), the relative importance of the other forage types for livestock is largely unknown. Nevertheless, it is clear that arable land allocations continue to be of critical importance as key forage areas for livestock during the dry season and increasingly during other times of the year too (Bennett and Barrett 2007).

In light of this and the continuing importance the South African government attaches to small-scale livestock ownership in developing sustainable rural livelihoods in the region (Government of South Africa 1997) there is an urgent need to understand how livestock make use of grazing resources in communal areas. This will provide an informed basis for the development of effective livestock management and development policies for the communal areas of South Africa. A crucial first step in this will be an assessment of existing grazing resources in these areas, particularly those that have a key role in maintaining livestock when forage is otherwise scarce, and how and when these are utilised by livestock. To this end this paper examines the extent to which the arable land allocations in two case study areas are utilised by livestock during the dry season at the landscape and plant community scale. The ecological and management implications of these findings are then discussed and policy recommendations are presented.

## Procedures

### *Study area*

The study area was the central region of Eastern Cape Province in South Africa (Figure 1).

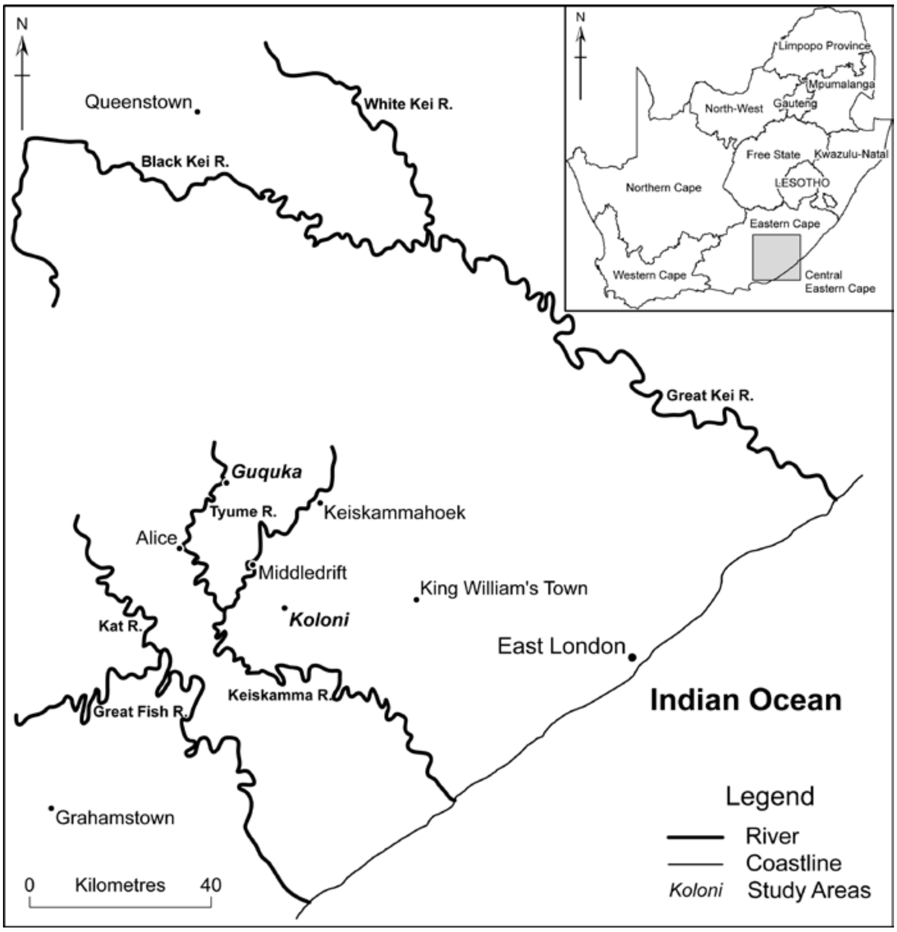


**Figure 1:** Overview of central Eastern Cape Province, South Africa

This is essentially an agro-pastoral region of relatively low potential. Rainfall is typically bimodal in pattern with peaks around November and March and varies from about 500 to over 1 200mm per annum, depending on topography and proximity to the coast (Marais 1975, Van Averbeke 2000). Although rainfed crop production is possible, it is marginal in most areas (Marais *et al*. 1975, Van Averbeke and Marais 1991). Maize is the dominant grain crop and may be intercropped with peas, beans and melons. Planting coincides with the start of the summer rains, usually around October, and harvesting takes place at the onset of the dry season, around May. Crop-livestock interactions are generally restricted to grazing of crop residues *in situ* during the dry season. Livestock ownership is focused on cattle, sheep and goats supplemented by limited maintenance of poultry and pigs at the homestead (Brown *et al*. 1975, ARDRI 1996). Ruminant animals graze on a free-ranging basis on communally held rangelands, which may be shared between several communities. The productivity of these rangelands can vary considerably both at a spatial and temporal level over relatively short distances (Trollope and Coetzee 1975). This variation is reflected in the classification of rangeland (veld) areas as sweetveld, sourveld or mixed veld (a mixture of sweet and sourveld in varying proportions). Sweetveld is distinguished from sourveld in that it remains relatively nutritious in the dry season, whereas sourveld declines in quality during the dry season (Tainton 1999). The central Eastern Cape region contains a good mixture of both rangeland types, with sweetveld dominating in lower rainfall areas such as the savanna and thicket biomes and sourveld becoming dominant in the grassland biomes at higher elevations, where there is greater rainfall (Trollope and Coetzee 1975, Beckerling *et al*. 1995).

Despite repeated crashes, livestock numbers have remained relatively constant in the region underlining their continuing importance in rural livelihoods (Hundleby *et al*. 1986, Ainslie 2002). In contrast crop production has declined considerably in recent decades, largely as a result of the withdrawal of the agricultural support schemes provided by the former regime (Eckert and Williams 1995). Thus, the local economy is now based on a mixture of livestock production and very limited crop production, with increasing levels of reliance on state transfers (mainly pensions) and remittances (Monde-Gweleta *et al*. 1997).

The study was focused on two communities, Guquka and Koloni (Figure 1). The villages were selected because they were known to be representative of a wide range of the social and ecological conditions that characterise the central Eastern Cape region and thus reflect the range of environments livestock are likely to encounter when foraging on arable land allocations in the region.

Guquka is located in the foothills of the Amatola Mountains at an elevation of around 840m asl. The village was established in the late 1890s by the colonial government, with allocation of both residential and arable land through quitrent tenure[1]. The village was subject to limited betterment planning during the early 1960s to the extent that rangeland and arable land were fenced off from the residential section of the village (Figure 2).

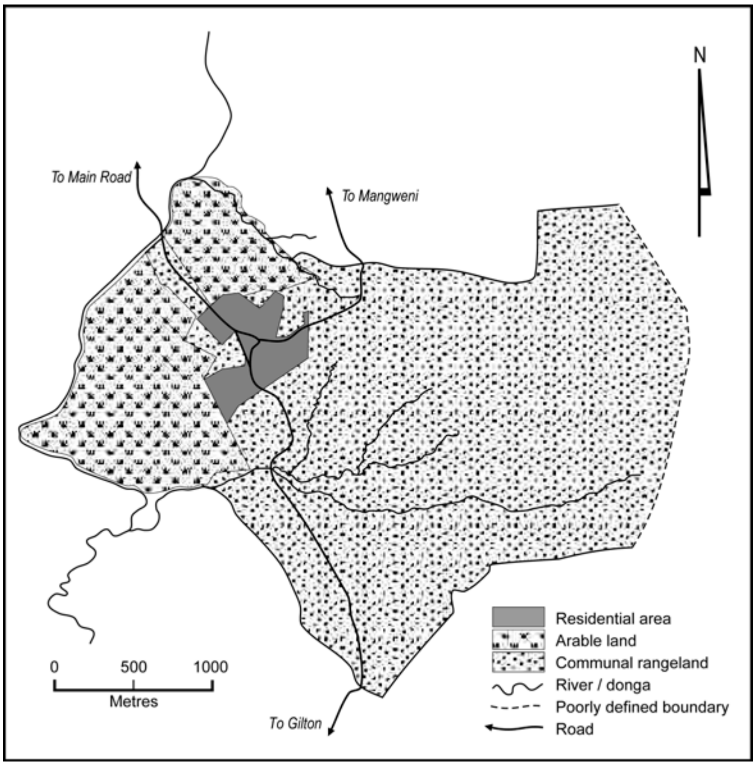


**Figure 2:** Land use patterns at Guquka village.

Around the same time black workers forcibly removed from white farms in the area were relocated at Guquka and also at the newly established and contiguous township of Kayalethu. This had the effect of considerably increasing pressure on local grazing

[1] Quitrent tenure was a form of individual land tenure introduced by the colonial government in the native areas during the 1840s, which provided secure tenure on payment of an annual fee to the local magistrate (Cokwana 1988).

resources as Kaylethu had no formal rangeland area of its own. As a result Guquka now shares an area of rangeland of approximately 400ha, not only with the neighbouring village of Gilton, but also informally with Kayalethu (Van Averbeke *et al*. 1998). The relatively steep topography of the area means that this rangeland varies in altitude from about 800m asl in the foothills of the Amatola mountains up to nearly 1 500m asl at its upper extent. Rangeland located at higher elevation, being subject to greater rainfall, consists of a combination of Döhne and Highland Sourveld (Acocks 1988). This is a typical type of sourveld in the region, which is characterised by becoming nutritionally poor during the dry season. In contrast the vegetation in the lower-lying areas, where the arable land allocations occur, consists of mixed veld – a mosaic of sourveld with areas of sweetveld intrusion (Story 1952). Although mean annual rainfall for the settlement as a whole is estimated to be in the order of 800mm per annum (Bennett 2002) the range of rainfall it experiences is considerable. Rainfall at the upper rangeland extent is in excess of 1 200 mm per annum (Marais 1975) whereas on the arable lands a figure of just 712 mm was recorded during 1998-99 as part of this study (Bennett 2002). Grazing of the rangeland area is undertaken by livestock from all three settlements in an essentially 'open-access' manner with little institutional control (Bennett and Barrett 2007). During the summer months most cattle from Guquka are allowed to free-range to the upper reaches of the rangeland and are rarely kraaled, whereas small-stock are kraaled on a nightly basis to protect against attack by wild animals and theft. Livestock ownership at Guquka is limited to just 38% of the population and total holdings amounted to 230 cattle, 400 sheep and 120 goats during 1996, the last date for which census data are available (ARDRI 1996, Bennett 2002).

The arable land allocation is some 150ha in extent and consists of 41 separate fields of varying size (2-5ha), the majority of which have been individually fenced-off by their owners at some stage (Figure 4). However, only 18 of these retain fully intact fencing around their perimeters (Bennett 2002). This places a limit on the amount of crop production that can occur as continuous grazing of the arable land area by trespassing cattle precludes crop production in unfenced fields (Bennett and Barrett 2007). Consequently, despite amenable rainfall, only about 20-25% of the available arable area is now cultivated in any given season (Van Averbeke *et al*. 1998). This low level of cultivation is a result not only of a lack of fencing but also of unsuitable topography and severe erosion in several fields as well as lack of inputs (Mbuti 2000). Efforts are made to reserve available forage on the arable lands for livestock from Guquka during the dry season. However, this is very difficult as cattle from Kayalethu gain continuous access to unfenced fields through gaps in the perimeter fencing (Bennett and Barrett 2007). Decisions to open and close the arable lands for grazing by Guquka's livestock are taken democratically on a community basis through a meeting of the Resident's Association (RA), which is formed from all adult members of the community and is responsible for key decisions concerning resource management (Bennett and Barrett 2007). Once the decision to officially open the fields has been made all owners are, in principal, obliged to make their fields available for grazing, including those that are fenced, where the gates are left open. Thus, despite the fencing that surrounds many individual fields, livestock from Guquka are able to gain access to almost all areas of the arable lands during the dry season (Bennett and Barrett 2007). Grazing is undertaken on a mixed basis by cattle and sheep and includes a limited number of cattle from Kayalethu (Bennett 2002).

Koloni, the second study village, is located on the coastal plateau, at an altitude of about 680m asl. The village was founded on mission land during the 1870s and, as at Guquka, residential and arable plots were allocated under secure quitrent tenure. The area was subject to intensive betterment planning both during the late 1930s and the early 1960s (Bantu Affairs Commission 1962, Ndlovu 1991). This involved not only the formal division of land into different categories through fencing (Figure 3) but also the fencing of the rangeland area into four separate grazing camps and the introduction of extensive contour banks to prevent erosion on the arable lands (Bantu Affairs Commission 1962).

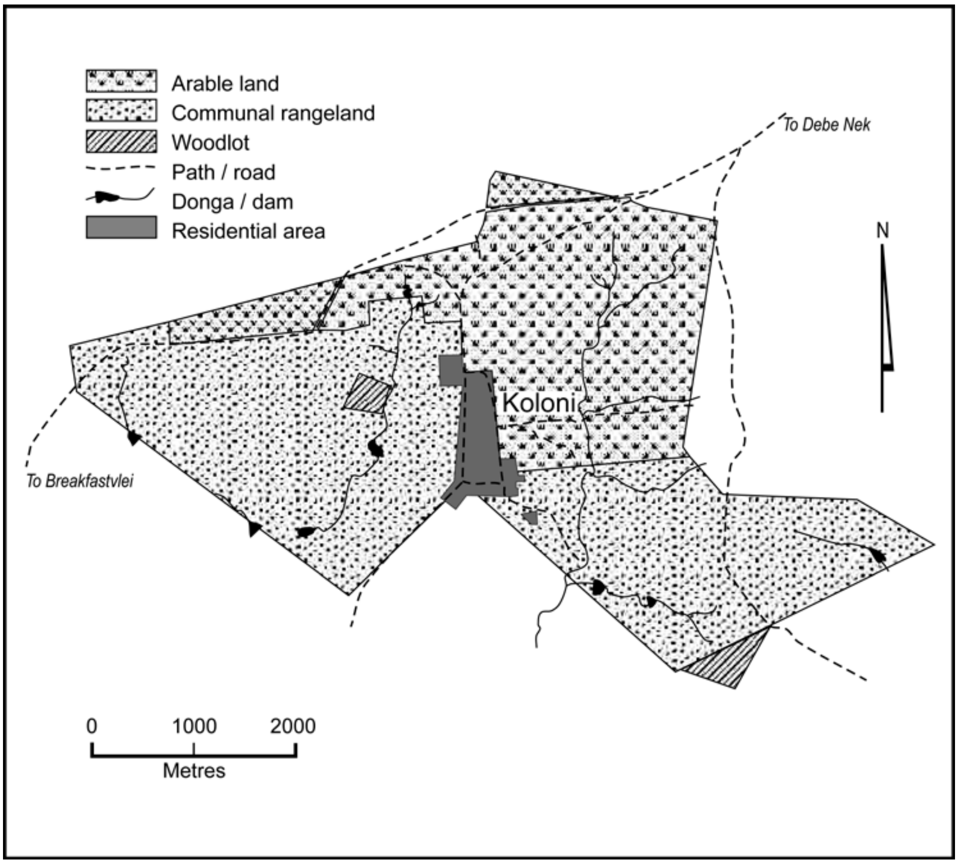


**Figure 3:** Land use patterns at Koloni village

Climatically, Koloni lies in a semi-arid region with an estimated annual potential evapotranspiration of 1 750mm and an aridity index of 0.27 (ARDRI 1994). Mean annual rainfall is estimated at between 500-530mm (Bantu Affairs Commission 1962, ARDRI 1994). Soils of the Glenrosa type dominate both the arable and grazing areas of the village. These support grassland or wooded grassland vegetation but are poorly suited to cultivation (ARDRI 1994). As a consequence of the underlying soil type and relatively low rainfall, the local rangeland is classified as sweetveld, specifically the False Thornveld of the Eastern Cape (Acocks 1988). The current rangeland holding amounts to some 650ha and belongs exclusively to the people of Koloni. The range camps are managed through limited rotational resting in which one of the camps is taken out of production for a year and the remaining three are grazed simultaneously (Goqwana and Scogings 1997). The decision about which camp to rest is taken democratically at a meeting of the RA. The RA is responsible for all decisions about land allocation and management at the village. Approximately, 64% of households at the village own some form of grazing livestock and total holdings amounted to 373 cattle, 508 sheep and 266 goats during 1999 (Bennett 2002).

Grazing of livestock takes place on the three camps in production throughout the year, although small stock and cattle with calves are kraaled overnight for protection from jackals and thieves (Bennett and Barrett 2007).

The arable land allocation constitutes an additional area of 400 ha and is divided into 112 unfenced fields of approximately 2.5 ha each (Figure 5), arranged in blocks, surrounded by open ‘commonage’ areas (Bennett 2002). Crop production has dwindled considerably over recent decades to the extent that only 5-15% of the available arable area is now cultivated in any given season and the remainder remains fallow in the long term (Van Averbeke *et al*. 1998). This is a result not only of the poor soils and relatively low rainfall but also lack of capital and equipment (Mbuti 2000, Verdoodt 2003). Consequently, arable vegetation is dominated by climax grassland-savanna with limited areas of crop residues (Figure 5). The arable allocation is made available as an additional forage reserve for livestock during the dry season. Given that individual fields are unfenced, arable grazing can only commence once all individuals who have engaged in crop production have completed harvesting. Decisions to open and close the arable lands for grazing are taken democratically on a community basis through a meeting of the RA. Grazing is restricted to cattle, as these are perceived as best able to utilise the available forage, and most animals are left to free-range on the fields without nightly kraaling (Bennett 2002).

## ***Methods***

### *Vegetation classification*

The arable land allocations at both villages were classified into different vegetation types as a precursor to the subsequent animal behaviour work. Initial land use classification was achieved largely by reference to 1: 10 000 and 1: 5000 aerial photographs of the two sites. The initial system of vegetation classification was based on broad categories developed during research by Lo Presti (1996) in nearby areas. These categories were further developed using a phytosociological approach to refine them on the basis of key species (Muller-Dombois and Ellenberg 1974, Goldsmith *et al*. 1986) noted during the ground verification exercise. On this basis a standardised vegetation classification system was devised for both villages. 1: 5000 scale ortho-photo maps of the arable land allocations were digitised using the ARC-INFO™ package and the different vegetation categories were then overlaid onto the map using ARC-VIEW™.

*Livestock counts*

Counts of free-ranging cattle and sheep on the arable land allocations were undertaken during the dry season of 1999. At Guquka 15 sets of consecutive weekly counts were obtained (beginning of June to middle of September 1999). At Koloni 21 consecutive weeks of observations were undertaken (beginning of June to late October 1999). Livestock counts were undertaken at 10am on randomly selected weekdays at each village. This involved walking the entirety of the arable allocation at each village and using dots to represent the position of individual cattle and sheep on A3 paper maps of the area derived from 1: 5000 aerial photographs of the sites (Bennnett 2002). This provided a comprehensive overview of weekly livestock distribution.

***Data analysis***

*Landscape preference*

Landscape preference was determined by comparing total count data from the arable lands with estimated counts from the rangeland. Counts for rangeland were estimated by assuming that livestock had just two foraging choices at the landscape scale (arable or range) and therefore that any animals not counted on the arable lands were present on the rangeland (calculated on a weekly basis as total village census figure for each livestock type minus weekly arable count). Estimation was necessary as the size of the arable land allocations in each case, combined with steep topography made conducting total counts in these areas logistically unrealistic. Overall preference was assessed by comparing actual and expected use of the arable and rangeland for each livestock species at each village using a replicated goodness-of-fit test (G-test), in which the each week of data was treated as a separate replicate (Sokal and Rohlf 1995). Weekly preference was assessed by comparing actual and expected use of the arable and rangeland on a weekly basis for each livestock type, using the standard G-test (Sokal and Rohlf 1995, Krebs 1999). In all cases the null hypothesis was that both sheep and cattle selected each landscape type at random.

*Vegetation preference*

Overall vegetation preference of cattle and sheep was assessed by comparing observed and expected counts of livestock in each vegetation category using simultaneous Bonferroni confidence intervals (Scogings *et al*. 1990, Breebaart *et al*. 2002) and through the calculation of forage ratios for each vegetation category (Krebs 1999). The forage ratio (FR) for each category was calculated as the proportion of livestock in each category divided by the proportion of each category available. The result is an index in which FR is >1 when the vegetation type is preferred and < 1 when the vegetation type is avoided (Krebs 1999). Bonferroni confidence intervals were also calculated for the FR indices according to Krebs (1999). This allowed determination of relative preference for different categories based on degree of overlap of confidence intervals and thus an overall hierarchy of relative vegetation preference to be established. For all Bonferroni confidence intervals an adjustment of $\alpha/n$ was used to facilitate multiple comparisons while maintaining a consistent overall error rate (Sokal and Rohlf 1995, Krebs 1999). In all cases these analyses made use of total counts (across all weeks) of sheep and cattle in each vegetation category.

Count data was also used to determine how cattle preference for each vegetation type changed over the course of the dry season. Data were divided into three broad groups representing the early, mid and late dry season respectively. Each stage grouped an equal number of weeks (n = 5 for Guquka and n =7 for Koloni). Bonferroni confidence intervals were then calculated separately for each of these time periods to facilitate determination of livestock preference at each stage. Treatment of the sheep data in this way was not undertaken as their sporadic occupancy of the arable lands meant that sub-division of the data provided little further resolution.

*Data considerations*

Determination of landscape preference using the total arable count data is may be subject to several inaccuracies. One of the most important of these lies in the assumption that livestock had only two landscape choices: arable and residential. It is quite possible that animals not present on the arable lands were kraaled (i.e. not foraging at all) or foraging within the residential area, which was not considered. The use of the census data to provide an accurate picture of total sheep and cattle numbers was also problematic at Guquka, as the most recent data that could be obtained was from 1996. At Koloni, however, accurate census data was available from 1999. An additional confounding factor at Guquka was the presence of a limited (but indeterminate) number of cattle from the neighbouring settlement of Kayalethu on the arable land allocations throughout the dry season, which served to inflate cattle counts slightly and possibly accentuate preference levels. Finally, it was assumed that all animals at both settlements could make equal use of all areas on an entirely free-ranging basis. For sheep this was unlikely to be true, as they tended to range relatively close to the residential area and thus were unlikely to make full use of the available rangeland particularly at Guquka. Also, in some cases livestock owners probably had a strong influence on animal ranging behaviour, particularly at Koloni where fencing and gates were used to enclose animals on range or arable areas.

## Results

### *Vegetation categories on arable land allocations*

Different vegetation categories were identified within the arable lands based on a combination of natural ecological and physical processes and land use history. Areas shaped by land use history can be broadly divided into those with no history of cultivation and those that have been cultivated at some point. At Koloni there are considerable areas where no previous cultivation has taken place, including the contour bunds both within and between fields and areas of common grazing which were designated when the fields were laid out in the nineteenth century. These areas support the commonage vegetation, a climax savanna-grassland characterised by many important grazing species as described in Table 1, as well as extensive *Acacia karroo* intrusion. Such open areas are not found within the confines of the arable land at Guquka. Erosion gullies (dongas), however, are found at both villages, although it is only at Koloni that they are able to support a distinct vegetation type. This vegetation includes several palatable species, as well as unpalatable succulents such as *Aloe ferox* and some limited ground vegetation (Table 1).

The remaining vegetation categories are found on the cultivated arable fields at each village and contain either crop residues or a mosaic of forbs and grassland vegetation in various stages of secondary succession. Four such vegetation categories were identified on the cultivated field areas at both villages, based on a combination of the dominant vegetation species they contained and the length of time the land had remained fallow. These include crop residues, recent fallow vegetation, *Sporobolus-Cynodon* grassland and *Hyparrhenia* grassland and basically represent the process of secondary succession from the point of initial cultivation to the formation of the climax vegetation type.

**Table 1:** Key species characterising different vegetation categories identified on arable land allocations at Guquka and Koloni.

| VEGETATION TYPE | KEY SPECIES |
|---|---|
| Donga vegetation | Riverine bush species including *Grewia occidentalis, Scuta myrtina*, *Acacia karroo* and *Aloe ferox* and grasses such as *Panicum maximum*. |
| Commonage vegetation | *Themeda triandra*, *Digitaria eriantha* and *Heteropogon contortus* sward and stands of *Acacia karroo*. |
| Crop residues | Maize residues, plus weed species such as *Datura Stramonium*, *Convolvulus sagittatus* and *Tagetes minuta* and annual grasses including *Digitaria sanguinalis, Eleusine coracana* and *Chloris virgata* |
| Recent fallow vegetation | Perennial grasses such as *Cynodon dactylon* and *Paspalum notatum* and forbs such as *Richardia brasiliensis* and *Ipomoea purpurea* |
| *Sporobolus-Cynodon* grassland | Perennial grass species: *Sporobolus africanus*, *Sporobolus fimbriatus*, *Cynodon dactylon* and *Eragrostis curvula* |
| *Hyparrhenia* grassland | *Hyparrhenia hirta* and *Acacia karroo* with patches of grazing-tolerant perennial grasses including *Eragrostis capensis*, *Digitaria eriantha* and *Sporobolus africanus*. |

The starting point in this succession process following cultivation is the crop residue vegetation category. In addition to maize residues it consists of often unpalatable dicotolyedenous weed species and a basal covering of annual grass species. The subsequent recent fallow and *Sporobolus-Cynodon* grassland vegetation are broadly characterized by the increasing dominance of perennial grass species at the expense of forbs. The final stage in the succession process on the arable lands at both villages is the *Hyparrhenia* grassland vegetation, dominated by dense, mono-specific stands of *Hyparrhenia hirta*. At Koloni this is supplemented with varying amounts of *Acacia karroo* intrusion. These are recognized as the dominant late succession species on uncultivated arable lands in South Africa (Theron 1991, Smits *et al*. 1999).

The proportion of each vegetation type during dry season 1999 is summarised for Guquka and Koloni in Figures 4 and 5 respectively.

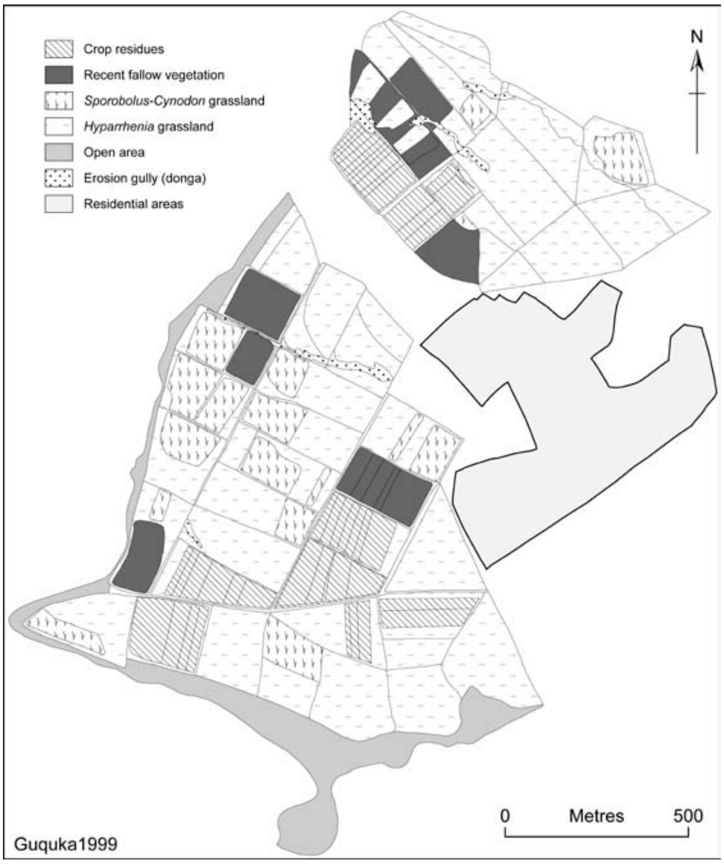


**Figure 4:** Proportion of vegetation types on arable land allocations at Guquka during dry season 1999.

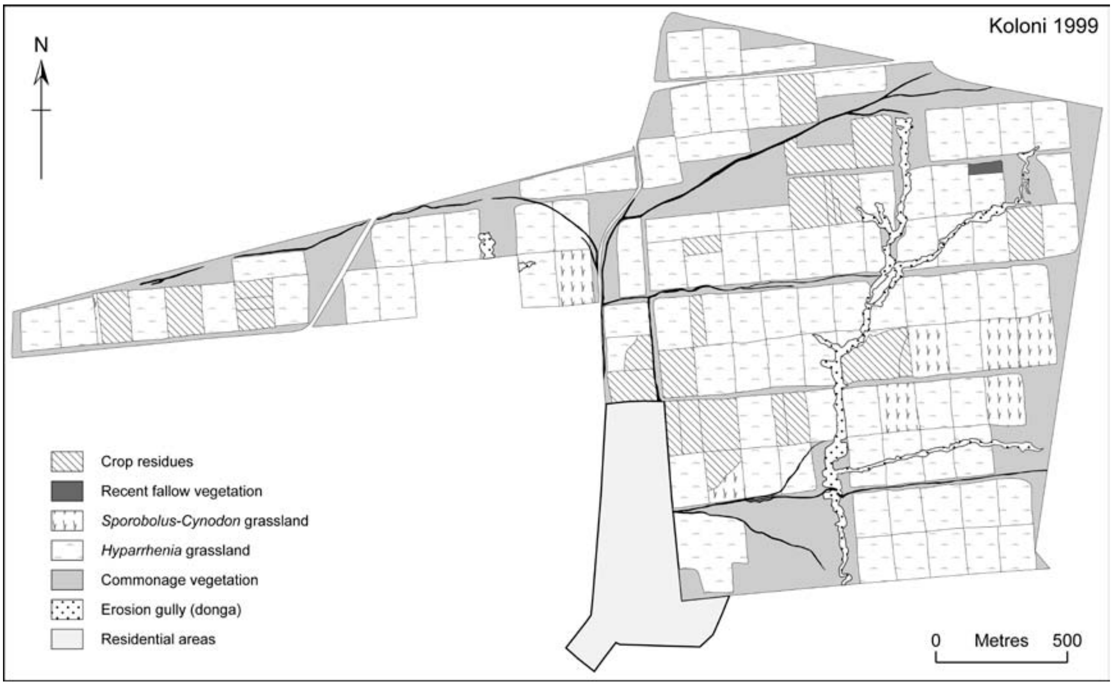

**Figure 5:** Proportion of vegetation types on arable land allocations at Koloni during dry season 1999.

***Landscape use by sheep and cattle***

Use of the G-test in assessment of any overall pattern of landscape use (arable vs range) by sheep at Guquka during the dry season was not possible due to several weeks with zero counts of animals on the arable lands. However, where counts were made, changes in weekly landscape selection are summarised in Table 2. In contrast cattle at Guquka displayed strong overall preference at the landscape scale during the course of the dry season (G = 1044.35, $p<0.001$). Changes in this level of preference are again broken down on a weekly basis in Table 2.

**Table 2:** Change in cattle and sheep preference for arable land at Guquka during the course of dry season 1999.

| | **SHEEP** | | | **CATTLE** | | |
|---|---|---|---|---|---|---|
| Week | Forage ratio | G-value | *P* | Forage ratio | G-value | *P* |
| 1 | 0.00 | - | - | 2.57 | 86.44 | <0.01 |
| 2 | 0.00 | - | - | 2.76 | 105.77 | <0.01 |
| 3 | 1.19 | 2.81 | NS | 4.15 | 308.40 | <0.01 |
| 4 | 1.03 | 0.06 | NS | 2.26 | 57.36 | <0.01 |
| 5 | 1.98 | 62.61 | <0.01 | 1.68 | 18.27 | <0.01 |
| 6 | 0.82 | 2.86 | NS | 3.10 | 146.23 | <0.01 |
| 7 | 1.36 | 9.39 | <0.01 | 3.39 | 185.07 | <0.01 |
| 8 | 0.36 | 40.88 | <0.01 | 2.44 | 73.69 | <0.01 |
| 9 | 1.04 | 0.14 | NS | 0.84 | 1.22 | NS |
| 10 | 0.06 | 112.97 | <0.01 | 0.89 | 0.54 | NS |
| 11 | 0.00 | - | - | 1.31 | 4.14 | <0.05 |
| 12 | 0.00 | - | - | 0.53 | 12.06 | <0.01 |
| 13 | 0.00 | - | - | 0.92 | 0.31 | NS |
| 14 | 1.49 | 17.37 | <0.01 | 0.32 | 27.85 | <0.01 |
| 15 | 0.26 | 32.48 | <0.01 | 0.45 | 16.99 | <0.01 |

- indicates sheep entirely absent from arable lands

It is clear that use of the arable lands by sheep was highly sporadic with patterns of significant preference and avoidance observed throughout the dry season. In contrast a far clearer picture of cattle choice at the landscape scale emerges. Cattle displayed very significant preference for the arable lands during the first 8 weeks of the dry season (June and July 1999). Then, following a brief period of non-significant (random) distribution at the landscape scale, ended the dry season by showing significant avoidance of the arable lands (August-September 1999).

Over the entire dry season cattle at Koloni displayed a significant level of landscape preference (G = 264.38, $p < 0.001$). The weekly change in this preference is summarised in Table 3.

**Table 3:** Change in cattle preference for arable land at Koloni during the course of dry season 1999.

| Week | Forage ratio | G-value | *P* |
|---|---|---|---|
| 1 | 1.61 | 77.51 | <0.01 |
| 2 | 0.75 | 14.71 | <0.01 |
| 3 | 1.11 | 2.55 | NS |
| 4 | 1.36 | 26.65 | <0.01 |
| 5 | 1.39 | 32.30 | <0.01 |
| 6 | 1.05 | 0.56 | NS |
| 7 | 1.25 | 13.70 | <0.01 |
| 8 | 1.12 | 3.27 | NS |
| 9 | 0.90 | 2.29 | NS |
| 10 | 1.16 | 5.46 | <0.05 |
| 11 | 0.93 | 0.94 | NS |
| 12 | 1.19 | 7.61 | <0.01 |
| 13 | 0.96 | 0.42 | NS |
| 14 | 1.28 | 16.97 | <0.01 |
| 15 | 0.96 | 0.29 | NS |
| 16 | 0.95 | 0.57 | NS |
| 17 | 0.91 | 1.68 | NS |
| 18 | 0.86 | 4.24 | <0.05 |
| 19 | 0.71 | 19.36 | <0.01 |
| 20 | 0.83 | 6.25 | <0.05 |
| 21 | 0.66 | 27.05 | <0.01 |

The weekly values for the assessment of landscape preference by cattle indicate either neutral selection or significant preference for the arable lands during the first 17 weeks of counts (June-September 1999). It was only during the last four weeks (October 1999) that cattle switched to significantly avoiding the arable lands.

***Vegetation preferences of sheep***

Comparison of Bonferroni confidence intervals for observed habitat use (Oi) by sheep compared with expected use (Pi) based on availability showed significant preference for crop residues and recent fallow vegetation and significant avoidance of both *Sporobolus*-*Cynodon* grassland and *Hyparrhenia* grassland overall (Table 4). In both cases the forage ratio (FR) values strongly reinforced these findings. Consideration of confidence intervals (CIs) for the FR values shows no overlap between those for crop residues and those for *Sporobolus*-*Cynodon* grassland and *Hyparrhenia* grassland, demonstrating that crop residues were significantly preferred by cattle to both of these grassland categories ($p$<0.05). Likewise, the distinct lack of overlap in respective CIs, showed that recent fallow vegetation was also significantly preferred to both of these grassland vegetation categories ($p$<0.05). However, the partial overlap in the CIs of crop residues and recent fallow vegetation and *Sporobolus*-*Cynodon* grassland and *Hyparrhenia* grassland required further statistical testing to demonstrate significant preference or avoidance. Chi-square tests showed that sheep significantly preferred recent fallow vegetation to crop residues ($\chi^2$ = 18.61, p <0.001) and also significantly preferred *Sporobolus*-*Cynodon* grassland to *Hyparrhenia* grassland ($\chi^2$ = 4.12, p = 0.04).

**Table 4:** Simultaneous Bonferroni Confidence Intervals (CI) for observed ($O_i$) vegetation use by sheep and for forage ratio (FR) values of different vegetation categories at Guquka during dry season 1999.

| Vegetation category | $P_i$ | $O_i$ | CI for $O_i$ | FR[†] | CI for FR |
|---|---|---|---|---|---|
| Crop residues | 0.17 | 0.56* | 0.51-0.61 | 3.31[a] | 3.02-3.60 |
| Recent fallow vegetation | 0.09 | 0.35* | 0.30-0.40 | 3.87[b] | 3.35-4.39 |
| *Sporobolus*-*Cynodon* grassland | 0.16 | 0.03* | 0.01-0.05 | 0.19[c] | 0.09-0.30 |
| *Hyparrhenia* grassland | 0.58 | 0.06* | 0.03-0.08 | 0.10[d] | 0.06-0.14 |

*Indicates observed value is significantly different than expected value (p<0.05)
[†]Values with different letters are significantly different from one another (p<0.05)

***Vegetation preferences of cattle***

**Table 5:** Simultaneous Bonferroni Confidence Intervals (CI) for observed ($O_i$) vegetation use by cattle and for forage ratio (FR) values of different vegetation categories at Guquka during dry season 1999.

| Vegetation category | $P_i$ | $O_i$ | CI for $O_i$ | FR[†] | CI for FR |
|---|---|---|---|---|---|
| Crop residues | 0.17 | 0.53* | 0.49-0.57 | 3.13[a] | 2.90-3.36 |
| Recent fallow vegetation | 0.09 | 0.09 | 0.07-0.12 | 1.04[b] | 0.79-1.28 |
| *Sporobolus-Cynodon* grassland | 0.16 | 0.15 | 0.12-0.17 | 0.91[b] | 0.74-1.08 |
| *Hyparrhenia* grassland | 0.58 | 0.23* | 0.19-0.26 | 0.39[c] | 0.34-0.45 |

*Indicates observed value is significantly different than expected value ($p<0.05$)
[†]Values with different letters are significantly different from one another ($p<0.05$)

At Guquka, Bonferroni confidence intervals for observed habitat use by cattle demonstrated that over the course of the dry season cattle significantly preferred crop residues and significantly avoided *Hyparrhenia* grassland but showed no significant preference or avoidance of either recent fallow vegetation or *Sporobolus-Cynodon* grassland (Table 5). For the FR values the lack of overlap of the CI of the crop residue index with any of the other three CIs suggested that this was significantly preferred to all the other vegetation types ($p<0.05$). Likewise the lack of overlap of the CI of the *Hyparrhenia* grassland FR with any of the other CIs showed that this was significantly avoided compared to all other vegetation types over the course of the dry season ($p<0.05$). However, the strong degree of overlap of the CIs for recent fallow vegetation and *Sporobolus-Cynodon* grassland suggested that there was no significant difference in the degree of preference cattle expressed for these two vegetation categories. This was confirmed by a chi-square test ($\chi^2 = 1.33$, $p = 0.25$).

**Table 6:** Simultaneous Bonferroni confidence intervals (CI) for observed ($O_i$) use by cattle of different vegetation categories at Guquka at different stages (early, mid and late) of dry season 1999.

| | | Early dry season | | Mid dry season | | Late dry season | |
|---|---|---|---|---|---|---|---|
| Vegetation category | $P_i$ | $O_i$ | CI for $O_i$ | $O_i$ | CI for $O_i$ | $O_i$ | CI for $O_i$ |
| Crop residues | 0.17 | 0.62* | 0.57-0.68 | 0.58* | 0.52-0.64 | 0.05* | 0.00-0.09 |
| Recent fallow vegetation | 0.09 | 0.16* | 0.12-0.20 | 0.02* | 0.00-0.04 | 0.07 | 0.02-0.13 |
| *Sporobolus-Cynodon* grassland | 0.16 | 0.10* | 0.07-0.14 | 0.11* | 0.07-0.15 | 0.44* | 0.33-0.55 |
| *Hyparrhenia* grassland | 0.58 | 0.12* | 0.08-0.16 | 0.29* | 0.23-0.35 | 0.44* | 0.33-0.55 |

*Indicates observed value is significantly different than expected value ($p<0.05$)

A more detailed overview of change in cattle habitat preference at Guquka over the course of dry season 1999 is provided in Table 6. Interestingly, although cattle exhibited significant preference for crop residues during both the early and mid dry season, this changed to significant avoidance by the late dry season. Conversely, despite *Sporobolus-Cynodon* grassland being mostly avoided by cattle, it was significantly selected in the late dry season. *Hyparrhenia* grassland was significantly avoided throughout.

**Table 7:** Simultaneous Bonferroni Confidence Intervals (CI) for observed ($O_i$) vegetation use by cattle and for forage ratio (FR) values of different vegetation categories at Koloni during dry season 1999.

| Vegetation category | $P_i$ | $O_i$ | CI for $O_i$ | FR[†] | CI for FR |
|---|---|---|---|---|---|
| Crop residues | 0.1155 | 0.2786* | 0.2475-0.3098 | 2.41[a] | 2.23-2.59 |
| Recent fallow vegetation | 0.0014 | 0.0007 | -0.0011-0.0024 | 0.47[bc] | -0.39-1.33 |
| *Sporobolus-Cynodon* grassland | 0.0465 | 0.0158* | 0.0072-0.0245 | 0.34[c] | 0.21-0.47 |
| *Hyparrhenia* grassland | 0.5697 | 0.2776* | 0.2466-0.3087 | 0.49[b] | 0.45-0.52 |
| Commonage vegetation | 0.2669 | 0.4272* | 0.3929-0.4616 | 1.60[d] | 1.51-1.69 |

*Indicates observed value is significantly different than expected value ($p<0.05$)
[†]Values with different letters are significantly different from one another ($p<0.05$)

At Koloni donga vegetation was excluded from determination of cattle habitat preference as no animals utilised it during the course of dry season (Table 7). For the remaining categories, Bonferroni confidence intervals for observed habitat use by cattle at Koloni demonstrated that over the course of the dry season cattle significantly preferred crop residues and commonage vegetation and significantly avoided *Sporobolus-Cynodon* and *Hyparrhenia* grassland. They expressed neutral selection of recent fallow vegetation. For the FR values the lack of overlap of the CI of the crop residue index with any of the other CIs showed these to be significantly preferred to all the other vegetation types ($p<0.05$). Likewise the lack of overlap of the CI of the commonage vegetation with any of the other CIs showed that this was also significantly preferred by cattle to all other vegetation types except crop residues ($p<0.05$). For the remaining categories, the significant amount of overlap of the CIs suggested further statistical testing was required to confirm significant preference. Chi-square tests demonstrated that there was no significant difference between the selection of recent fallow vegetation and *Sporobolus-Cynodon* grassland ($\chi^2$ = 0.09, p = 0.77) or *Hyparrhenia* grassland ($\chi^2$ = 0.57, p = 0.45). However, *Hyparrhenia* grassland was found to be significantly preferred to *Sporobolus-Cynodon* grassland ($\chi^2$ = 9.10, p = 0.003).

**Table 8:** Simultaneous Bonferroni Confidence Intervals (CI) for observed ($O_i$) use by cattle of different vegetation categories at Koloni at different stages (early, mid and late) of dry season 1999.

| | | Early dry season | | Mid dry season | | Late dry season | |
|---|---|---|---|---|---|---|---|
| Vegetation category | $P_i$ | $O_i$ | CI for $O_i$ | $O_i$ | CI for $O_i$ | $O_i$ | CI for $O_i$ |
| Crop residues | 0.115 | 0.323* | 0.266-0.379 | 0.256* | 0.207-0.306 | 0.244* | 0.188-0.299 |
| Recent fallow vegetation | 0.001 | 0.000* | NA | 0.000* | NA | 0.002 | -0.004-0.009 |
| *Sporobolus-Cynodon* grassland | 0.047 | 0.005* | -0.003-0.014 | 0.010* | -0.001-0.021 | 0.039 | 0.014-0.065 |
| *Hyparrhenia* grassland | 0.570 | 0.304* | 0.249-0.359 | 0.265* | 0.215-0.315 | 0.256* | 0.199-0.312 |
| Commonage vegetation | 0.267 | 0.369* | 0.311-0.426 | 0.469* | 0.412-0.525 | 0.459* | 0.394-0.523 |

*Indicates value is significantly different than expected ($p<0.05$)
NA = Not applicable due to absence of cattle

Cattle habitat use remained relatively consistent over the course of the dry season (Table 8). There was significant selection for both crop residues and commonage vegetation and significant avoidance of *Hyparrhenia* grassland throughout. The only notable change in cattle preference was the switch from avoidance of *Sporobolus-Cynodon* grassland during the early and mid dry season to neutral selection late on. Data for recent fallow vegetation are inconclusive as no animals were recorded in the category for the majority of the dry season.

## Discussion

### ***Foraging at the landscape scale.***

Objective assessment of overall selection by sheep at the landscape scale was confounded at Guquka by their relatively sporadic use of the arable lands and at Koloni by their complete absence from the arable lands. The absence of sheep at Koloni was a result of owners completely excluding them from the arable land allocations during the dry season based on a perceived need to preserve the arable forage for cattle and not to habituate sheep to trespass onto the arable lands for fear of crop damage during the growing season (Bennett, 2002). At Guquka the landscape selection data suggest that, for at least brief periods of dry season 1999, sheep expressed preference for the arable lands over rangeland. However, this is confounded by inaccurate assessment of the extent over which animals can truly free-range in the determination of expected landscape use. It may also be possible that the sporadic use of the arable lands by sheep resulted from some owners exercising control over sheep movement, which raises questions over the degree to which the animals at Guquka could really be considered 'free-ranging' at the landscape scale. Thus, all that can realistically be concluded is that sheep at Guquka do make considerable use of the arable lands during the early stages of the dry season.

For cattle, significant overall preference was expressed for the arable land allocations during the dry season at both Guquka and Koloni. Moreover, the trends in cattle preference over the course of the dry season were largely similar at both villages with preference on a weekly basis being expressed mostly during the early stages of the dry season. This was particularly marked at Guquka, were arable preference was largely limited to the first 8 weeks of the dry season (June and July), which was when crop residues were available (Bennett 2002). Following their exhaustion (week 11) cattle only were only neutral in their selection or avoided the area completely. At Koloni selection patterns were less marked, but the overall trend of initial preference followed by avoidance late in the season was still apparent. Importantly, weekly counts at Koloni extended over a much longer period than at Guquka. Only the first 17 weeks (June-September) were representative of the accepted 'dry season' and animals demonstrated preference or neutral selection throughout this period. This is consistent with the continued availability of all vegetation types at Koloni throughout this period (Bennett 2002). However, at both villages it is notoriously difficult to relate animal preference at this scale only to forage availability and quality due to the myriad of other, often conflicting, factors (proximity to water, topography and home range behaviour), which can affect animal landscape choice (Senft *et al*. 1987, Stuth *et al*. 1993, Bailey *et al*. 1996). Interestingly, the avoidance of the arable lands by cattle during the last four weeks of monitoring (October 1999) coincided with the onset of the summer rains and probably represented the active removal by owners of cattle to the recovering range camps.

***Vegetation preference***

For sheep the significant preference shown for crop residues and recent fallow vegetation at Guquka is in marked contrast to the significant avoidance of both grassland vegetation categories. These foraging preferences can be explained through the mechanics of sheep grazing. Sheep are adapted to be selective grazers and the allometry of their food intake restricts them to feeding on grasses and herbs characterised by a short sward height and which do not become too tall, stemmy or fibrous (Allden and Whittaker 1970, Hanley 1982, Illius and Gordon, 1987). The annual grasses and herbaceous plants that grow among the crop residues, and dominate the recent fallow vegetation, are ideally suited to the rapid, small bites of sheep. The strong preference identified in sheep for the crop residues is also generally supported by other studies. Van Zyl and Dannhauser (2005), Brand *et al*. (1997) and Aitchison (1997) all report the use of crop residues by sheep in dry lands environments and Gertenbach *et al*. (1998) demonstrate how the efficiency of maize residue utilisation by sheep in South Africa can be improved by mixed grazing with cattle. In contrast, the relatively limited conjoint grazing of the arable lands by both cattle and sheep observed in this study suggests that the dry season forage on the arable land allocations is not being used as effectively as it might be in communal grazing areas of the central Eastern Cape.

For cattle overall vegetation selection patterns during the dry season were remarkably similar at both villages. Significant overall preference was expressed for crop residues and significant overall avoidance for *Hyparrhenia* grassland. These two vegetation categories appeared to represent extreme ends of the preference scale. For the remaining successional vegetation categories the picture is less clear. Selection for recent fallow vegetation was neutral at both sites whereas cattle displayed neutral selection for *Sporobolus-Cynodon* grassland at Guquka and significantly avoided it at Koloni. Finally at Koloni the commonage vegetation was significantly preferred. Moreover, it was clear that in many cases cattle preference for these vegetation categories were not static but rather dynamic and driven by the opportunistic foraging patterns of animals at different stages of the dry season. For example, *Sporobolus-Cynodon* grassland was avoided in the early and middle stages of the dry season at both villages whereas in the late dry season it was actually preferred at Guquka and neutrally selected at Koloni. Likewise, crop residues, although consistently favoured at Koloni were avoided at Guquka in the late dry season. Thus, overall preference indices masked important changes in preference for some vegetation types during the course of the season.

For cattle vegetation preference can be reasonably well explained in terms of both the palatability and availability of key grazing species and how this changes during the course of the dry season. For example, the commonage vegetation at Koloni is largely dominated by key grass species such as *Themeda triandra*, *Digitaria eriantha* and *Heteropogon contortus*, which are highly palatable (Van Oudtshoorn, 1992) and would therefore be expected to be a preferred forage type. In contrast, *Hyparrhenia* grassland is dominated by a single species, *Hyparrhenia hirta*, which is recognised to form tall, rank swards on old lands (Theron 1991, Smits *et al*. 1999). Rank swards of this type are known to depress animal intake rates (Ruyle *et al*. 1987, Laca *et al*. 1992, Ginnett *et al*. 1999). *Hyparrhenia* grassland is also widely acknowledged to be of poor nutritional quality for livestock during the dry season (Smith 1961). Consequently, cattle at both villages largely avoided this grassland type throughout the dry season unless they were presented with no alternative. This also seems to have been true of the *Sporobolus*-*Cynodon* grassland at Guquka, which was only selected in any quantity at the end of the dry season once the crop residues and recent fallow vegetation were completely exhausted (Bennett, 2002). This feeding behaviour is corroborated by the work of Wallis de Vries and Daleboudt (1994), who found that cattle selected mature feeding sites only when the exclusive use of short, vegetative patches did not allow them to fulfil their daily intake requirements.

Overall these findings provide an important insight into dry season foraging preferences on arable land allocations in the region. They demonstrate that both cattle and sheep show strong preference for key vegetation categories such as crop residues whereas later succession grassland types are completely avoided by sheep and only become preferred or neutrally selected by cattle once more preferred vegetation types have become depleted. However, it this heterogeneity of vegetation types, representing both the various stages of secondary succession as well as uncultivated areas, which is vital in enabling cattle to switch opportunistically between different vegetation types. This may occur within a particular stage of the dry season such that animals are demonstrating preference for two vegetation types simultaneously (e.g. crop residues and commonage vegetation at Koloni), possibly in response to factors such as distance to forage type or home range behaviour (Bailey *et al*., 1996; Rouget *et al*., 1998). It may also occur over time in response to the exhaustion of a particular vegetation type or a decline in its productivity, as demonstrated by the switch to grazing of *Sporobolus*-*Cynodon* grassland at Guquka following the depletion of available crop residues. Such marked switches in forage preference over time were not a feature of cattle grazing at Koloni, where preference was likely to have been sustained by the greater availability of forage in vegetation categories throughout the dry season (Bennett 2002).

**Conclusions**

These findings underline the considerable value of the arable land allocations in the central Eastern Cape region in their role as 'key resource areas' (Scoones, 1995; Illius and O'Connor, 1999) for livestock during the dry season. Although no clear pattern of sheep preference emerges at the landscape scale, it is apparent that for cattle these areas provide a critical grazing resource particularly early in the dry season. Moreover, at the vegetation scale a general forage-preference hierarchy emerges for cattle and sheep on arable lands, which for cattle varies over the course of the dry season. Indeed, the results reinforce the suggestion of Stuth *et al*. (1993), that intra-landscape foraging decisions at the plant community scale are of greater importance than those at the landscape scale in environments such as these where, the opportunity to range over substantial areas no longer exists. Thus, although betterment planning has greatly limited the extent and range of habitats available to free-ranging livestock in communal areas of central Eastern Cape Province, these findings suggest that a form of 'opportunistic' foraging by livestock still occurs. However, rather than manifesting itself at the broader scale as movement between distinct habitat types it occurs at the vegetation category level within a defined landscape/habitat. Thus, the multiple niches that different habitats provide for free-ranging livestock in other studies (e.g. Scoones 1995) find parallel here with the different vegetation types resulting primarily from the succession process following cultivation.

These findings also have significant implications for range management policy in communal areas of this region. The limited overlap found in the grazing requirements of cattle and sheep on the arable land allocations suggests that conjoint grazing of these areas by the two species would be the most effective means of resource utilisation. This is supported by the work of Coppock *et al*. (1986) in dryland communal areas of Kenya. However, such a recommendation would need to be applied on a case-by-case basis as social factors of the type outlined previously may limit the practicality of conjoint grazing in some instances.

Moreover, during the dry season when forage availability and quality is often limited, it is the range of different vegetation types available on the arable land allocations, which facilitates the continued exploitation of these areas by different livestock species. Within this a distinct grazing preference hierarchy is evident headed by early succession categories such as crop residues and non-cultivated areas (commonage vegetation), which are preferentially utilised until their depletion forces a switch to more mature sward types. Given that crop residues are the preferred forage type of both cattle and sheep, an obvious strategy in the management of these arable forage reserves might be to increase cultivation. However, this is unlikely to be realistic in an environment of limited and generally declining crop production (Eckert and Williams 1995, Mbuti 2000). A more feasible alternative might be to manage the later succession grassland such that it is more amenable to grazing during the dry season through either spring burning or controlled summer grazing (Smith, 1961, Bailey *et al*. 1998, Tainton 1999). Irrespective, it is important that arable land allocations in the region continue to be maintained as a mosaic of vegetation types at different stages of secondary grassland succession. This will allow livestock, particularly cattle, to opportunistically 'switch' between vegetation categories in response to changes in forage availability and quality during the dry season.

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