CHAPTER 3
ACTIVITY

How could I watch them they're frightened of men?
What were they doing? Where are they when?
On horseback I searched in sun and moonlight.
I recorded activity, "trot, out of sight".
"Grazing, grazing, defecate, rest,
Walking, drinking (sun's in the west)".
They spend most time fulfilling one need.
Grazing, grazing, foraging, feed.

3.1 Introduction

Little is known about the amount of time invested (i.e. time-budget) by feral horses in activities which allow them to satisfy their basic requirements for food, water, movement and rest (Boy & Duncan, 1980). Diurnal and nocturnal activity patterns have been reported for free-ranging but managed horses (Kownacki et al., 1978; Duncan, 1980). For feral horses diurnal but not nocturnal activity patterns were described by Salter & Hudson (1979) and Berger (1986), whereas Keiper & Keenan (1980) described nocturnal but not diurnal activity. There have been no studies of both diurnal and nocturnal time-budgets of unhabituated feral horses. This information is necessary to fully understand the ecology of feral horses in central Australia.

How do feral horses in central Australia invest their time to satisfy their basic requirements for food, water, movement and rest? Which activities take most time? Are there seasonal changes, differences between age classes and social classes in time-budget? In this chapter I answer these questions and describe how horses in central Australia spend their time. This description illustrates well the type of difficulties encountered during my studies. For example before answering the above questions I needed to determine how best to obtain time-budget information for such wild horses in such expansive and rugged country.

3.2 Methods

Data were obtained from ground-based transects and radio-tracking. Many difficulties were encountered, particularly with radio-tracking. So it was necessary to develop special data-gathering techniques suitable for central Australian feral horses.

3.2.1 Radio-tracking

a) Immobilisation and collaring

To supplement the data recorded during transects and collect more detailed information on activity five male adult horses were immobilised and fitted with radio-transmitting collars. The horses were tranquillised using a dart gun and the drug "Scoline" (Suxamethonium chloride, 50 mg/ml). Between 3.5 and 3.7 ml of Scoline was required to immobilise the stallions. For predictable results it is essential for the horse to be relaxed when darted. It was virtually impossible to approach horses close enough for darting while they grazed. Horses were therefore darted as they came to drink at Top Bore. I waited in ambush (up in a corkwood tree) for a group to come to drink and darted the stallion as he took his first sip of water. At that time horses appear to have decided that there is no danger. Scoline is the only permissible drug which acts quickly enough for use in rugged country. Other drugs take 15 minutes or more to effect immobilisation, during which time horses could travel long distances. Scoline acts within 2 minutes, immobilising the horse for 4 - 5 minutes. Blind-folding of the darted horse enables collaring to continue after the horse wakes. Collaring generally took 10 - 15 minutes, thus enabling the horse to return immediately to its group. Scoline is highly weight-specific with a narrow range between underdose and overdose. Male adult horses, being more uniform in size and condition than female horses, were better suited to being effectively immobilised.

b) Difficulties following horses

The radio-tracking equipment allowed me to find and follow the collared horses and members of their social groups to observe and record their behaviour. "AVM" transmitters and receivers operating in the 150 to 151 MHz range were used. The transmitters were equipped with activity sensors that caused the receiver to emit irregular beeps when the horse was moving quickly or shaking its head. This was useful when I was trying to approach the horses. Sometimes they saw me before I saw them and the irregular beep would warn me of this. I could stop still and crouch down until the beeps were regular again. Although the activity sensor was valuable in this respect I have a suspicion that it was the cause of intermittent transmitter failure. On two occasions I could not receive signals from collared horses that were only 100 m from me. After shaking his head "Brumby One" appeared to restart his transmitter. It is impossible to know how many of the times failure to detect signals during the study were due to transmitter failure.

The initial plan was to select a different group each month, follow it for 24 hours and sample the diurnal and nocturnal activity of each individual. All going well this would have allowed me to follow each group 3 times (spaced 5 months apart) during a 15 month period (July 1985 to October 1986). Difficulties associated with immobilisation to fit collars and subsequently locating and observing these very wary horses reduced the number of successful observation periods substantially (see Appendix I).

The rugged terrain and intermittent transmitter failure made it extremely difficult to detect signals from all collared horses during any one field trip. I was therefore unable to preselect any particular group for observation and the initial plan to follow a different group each month was abandoned. Instead, on the day before full moon the radio-marked group closest to Top Bore was located and followed for as long as possible up to 24 hours.

c) Cattle collared too

To allow comparison between the movement and activity of horses and cattle four cattle (2 bulls and 2 cows) were fitted with radio-transmitters. Both bulls appeared to have damaged their transmitters, perhaps by fighting or rubbing on trees because they failed to transmit one week after fitting. Limited data were obtained by following the cows.

Table 3.1: Activities recorded during ground based transects and observations of radio-marked horses and their companions.

Activity	Description of animal	During transects	Continuous observation
Sleep	Eyes closed, standing with neck just below horizontal or lying	No	Yes
Lying	Lying recumbent or laterally	Yes	Yes
Stand	All four legs immobile and supporting the resting or alert animal	Yes	Yes
Drink	Taking in water through mouth	Yes	Yes
Nurse	Standing letting juvenile drink milk	No	Yes
Suck	Obtaining milk from mother	Yes	Yes
Browse	Feeding on trees or shrubs (woody plants)	Yes	Yes
Graze	May be walking or standing but head down feeding on grass or other herbaceous vegetation	Yes	Yes
Walk	Moving in a 4 beat gait with neck parallel to the ground or raised. Not feeding.	Yes	Yes
Roll	Rubbing back or sides in sand, water or mud	No	Yes
Trot	Moving in a two beat gait faster than a walk with diagonally opposite legs moving simultaneously.	Yes	Yes
Gallop	Moving faster than a trot in a 3 beat gait.	Yes	Yes
Mating	Copulating	Yes	Yes
Fight	Kicking, biting, rearing, chasing or pushing another horse.	Yes	Yes
Play		Yes	Yes
Fright	Responding to the presence of the observer	Yes	Yes
In Shade	In the shade of a tree	Yes	Yes
Defecate		No	Yes
Urinate		No	Yes
Groom	Scratching or licking another horse	No	Yes
Auto-groom	Scratching or licking self	No	Yes
Stretch	Extending legs out in front or behind body to stretch them	No	Yes
Rub	Scratching body on a tree	No	Yes
Look	Alert, looking around, checking for danger	No	Yes
Unknown	Horse cannot be seen well enough to determine activity	Yes	Yes

d) Recording activity

Observations were conducted when the moon was fullest so that horses and cows could be watched at night using high powered binoculars. A list of activities to be recorded was prepared using the literature and after initial observations of horses and cattle. The activities are listed in Table 3.1. By using a Sharp Pocket Computer, I could record information for all members of a group simultaneously. The largest group observed in this way numbered 8 and the smallest 3 individuals. When a horse changed activity the observer simply pressed a function key on the computer corresponding to the particular horse then pressed another to record the activity. The computer automatically recorded the time from an internal clock. The start and finish times were recorded for each activity so that the time spent in any activity and the sequence of activities could be determined for each individual.

I required an assistant for observation of horses for 24 hour periods. The selected group was initially located on horse-back and a camp set up for one observer to rest while the other followed the group of horses. After completion of a 3 hour period of recording the first observer returned to the camp to let the other observer know where the horses were. Using the radio-tracking gear the second observer located the group once more to record activity starting 2 hours after the time when the first observer ceased. If the horses had moved a substantial distance then the camp and ridden horses were moved closer to the site of observation. Generally the only appreciable moves occurred when the horses walked in to drink or out from water to feed, or if they were disturbed by the observer.

For successful observation it was essential not to disturb the horses. I was not able to habituate the horses to being observed. While recording data my assistants and I had to ensure that we were not seen by the horses. This could be achieved by standing or sitting very still, close to trees or shrubs out of full moonlight or sunlight. Horses were usually more than 70 m from observers. However, on one occasion they grazed within 10 m of me unaware of my presence until I moved my finger slightly. They took fright and galloped 20 m away. Apparently they were unable to distinguish me from the tree that I stood beside. However, the slightest (but sudden) movement was detected. For most groups on most occasions any indication of danger caused them quickly to move (walk or trot) 2 or 3 km. Once disturbed their awareness appeared heightened, they were very difficult to reapproach and often required a day or two to settle down.

3.2.2 Transects

The method for patrolling transects is described in detail in chapter 2. When a group of horses was first sighted during transects the activity of each horse was recorded. The list of activities (Table 3.1) that were recorded was prepared after consulting the literature with a view to having compatibility with other published studies. Activities were also added to the list after I conducted trial observations. Transect data were analysed to search for long term patterns in activity. The method gives a broad look at the activity of the horse population within the area covered by transects.

3.3 Results

3.3.1 Direct observations

The transect data can tell us the activities only of the horses that are seen in the area covered by transects. So if horses are grazing outside the area then the data do not give a good idea of how a horse spends its time. By following radio-marked horses I was able to obtain a more detailed picture of feral horse activity because wherever the horses went I followed.

Appendix I lists the occasions when horses or cattle were followed and their activities recorded. Horse activity was recorded during 63 of the 97 hours spent following horses. Since data were recorded simultaneously for all horses in each group the total equivalent amount of observation time was 309 horse-hours. On only 3 out of 13 attempts were horses followed long enough to adequately sample both nocturnal and diurnal activities during a single 24 hour period. Analyses of these data indicate that horses spend most of their time grazing, standing or walking. This is consistent with the findings from transects. However, the mean proportion of time spent grazing for individual adult horses (73 ± 26% to 81 ± 11%, $\bar{x} \pm$ SD) was somewhat higher than the mean proportion of horses seen grazing along transects (52 ± 18%, $\bar{x} \pm$ SD) during 3 month periods. The estimates of overall time spent grazing derived from transect data were probably biased due to inadequate transect coverage in time and space. Transects did not adequately cover hilly country distant from water nor could transects be run at night. I believe better estimates of overall time spent grazing for individual horses were obtained by the direct observation method. Figure 3.1 through to Figure 3.5 show that grazing takes up the greatest proportion of any period and there appears to be no consistent diurnal or nocturnal pattern of activity. The lowest estimates for grazing were recorded in the afternoon for "Bay Brumby's" group because they walked to Top Bore for a drink (3 km) then returned to where they had been grazing. The excursion to water certainly cut down the available time for grazing. However, their overall mean time spent grazing was similar to that of the other groups (Table 3.2).

Table 3.2: Time spent grazing by adult members of 3 radio-marked groups of horses.

Horse	Percent of time spent grazing during 4 hour periods of the day and night ($\bar{x} \pm SD$)
"Bay Brumby" (stallion)	73 ± 26
Bay-brown mare	77 ± 37
Young stallion	76 ± 6
"Black Brumby" (old stallion)	79 ± 11
Chestnut mare	71 ± 10
Bay mare	81 ± 11
"Brumby One" (stallion)	74 ± 16
Grey mare	75 ± 21
Baldy mare	81 ± 11
Bay mare	74 ± 13

a) Drinking frequency

The 3 groups were followed for a total of 59 hours and only one group was observed to walk in to drink. This indicates that these horses were drinking less frequently than once every 30 hours. Combining data for all horse groups (97 hours) shows that horses were observed to drink only 3 times indicating a drinking frequency of once every 32 hours.

b) Time-budget pattern

Although one group was observed just after the spring rain, one when conditions were extremely dry and the other after good winter rain there was no significant difference between the time-budgets of the adults from the three groups (Figure 3.4). Nor was there any difference between diurnal and nocturnal activity (Figure 3.5).

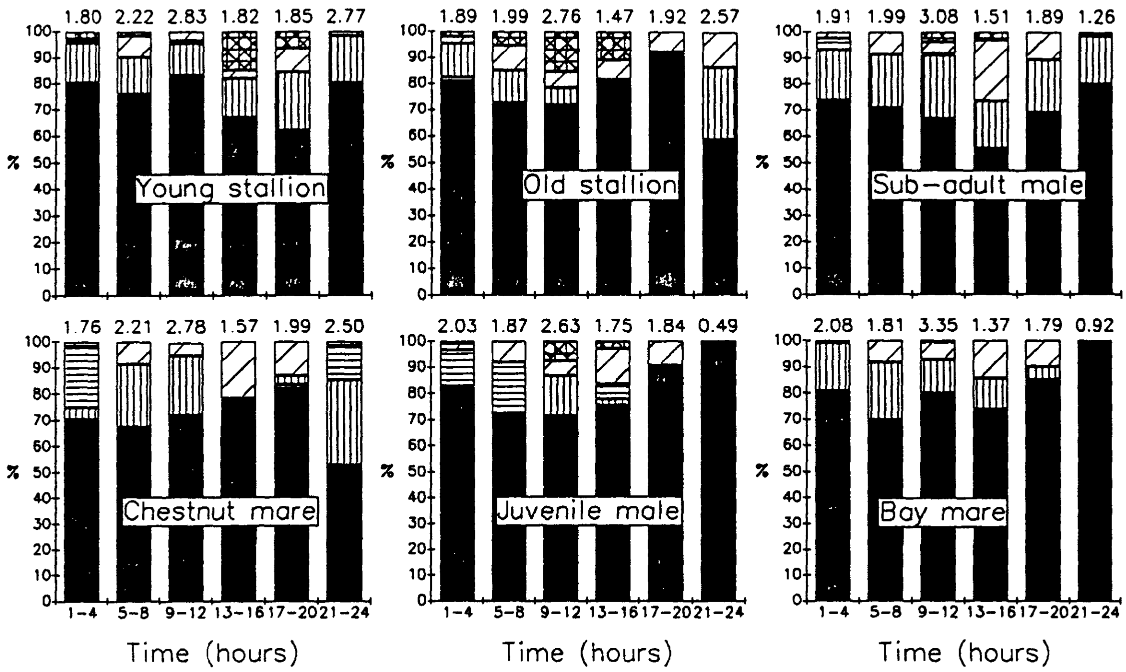

Figure 3.1: Proportion of observation time (above) spent grazing (black), standing (I I), lying (==), walking (//) or other (X) for "Black Brumby's" (Old stallion) group during 24 hours beginning at 1000 h on the 27 November 1985.

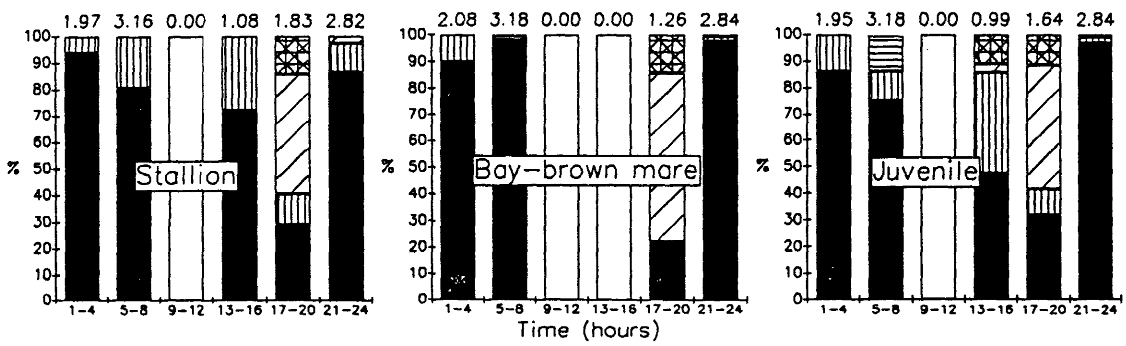

Figure 3.2: Proportion of time spent grazing (black), standing (I I), lying (==), walking (//), other (X) or no obs. (clear) for "Bay Brumby's" (Stallion) group during 24 hours beginning at 1430 hours on the 27th of March 1986.

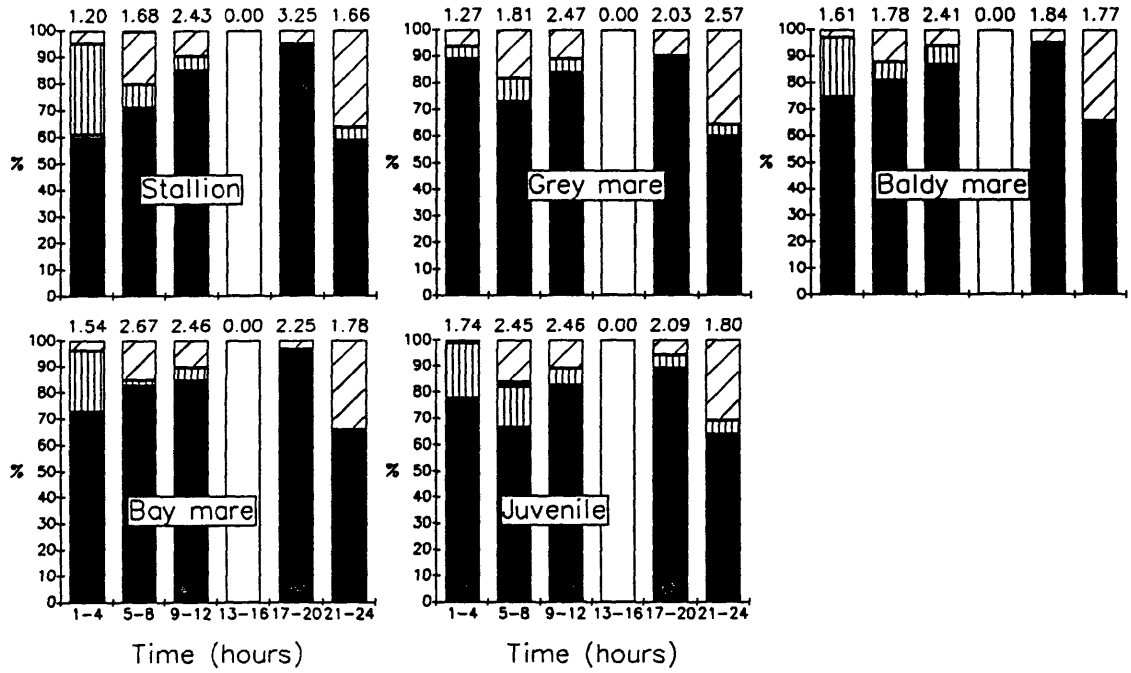

Figure 3.3: Proportion of time spent grazing (black), standing (I I), lying (==), walking (//) or other (X) for "Brumby One's" (Stallion) group during 24 hours beginning at 1649 hours on the 19th of August 1986.

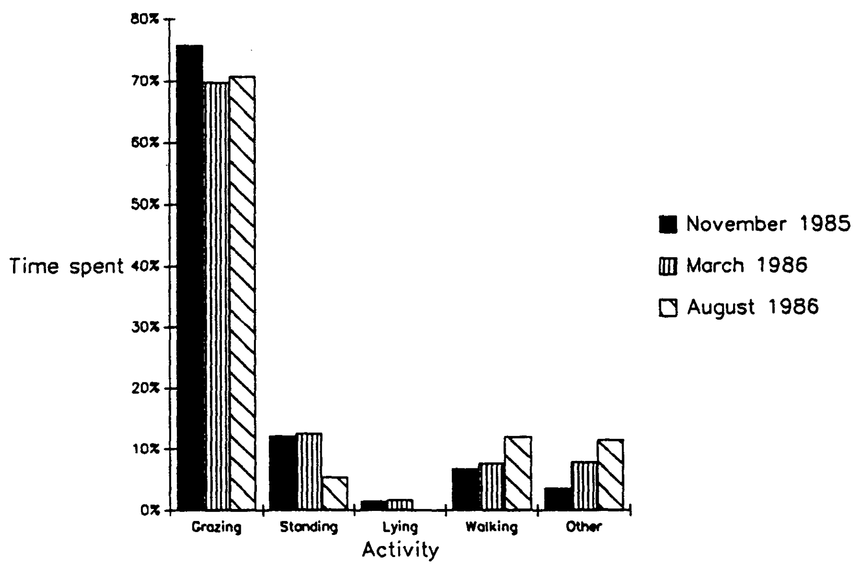

Figure 3.4: Comparison of activity for adults of 3 groups of horses. All individual times were combined. Data was collected by observing radio-collared horses.

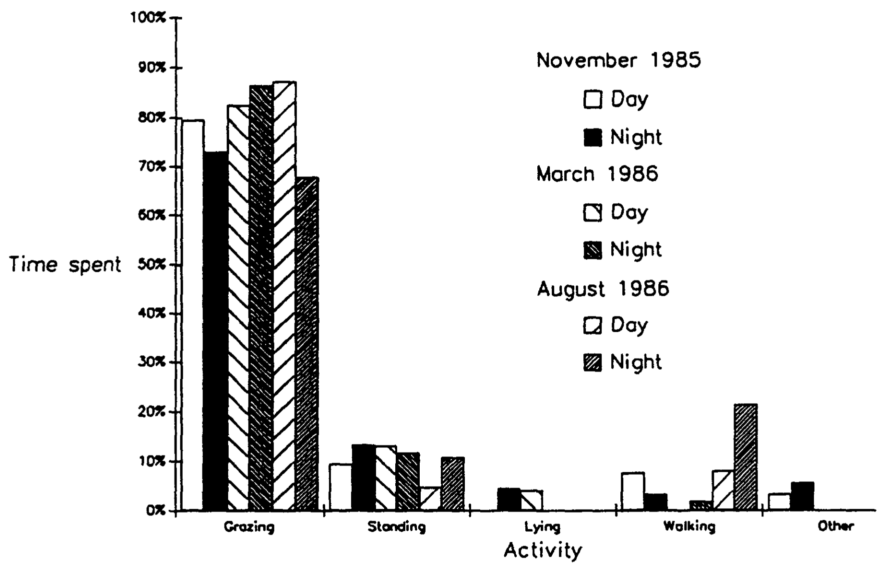

Figure 3.5: Comparison of diurnal and nocturnal activity for the adults of 3 radio-marked groups of horses. All individual times were combined. Night was 2100 to 0400 h while day was 0800 to 1700 h.

3.3.2 Transects

Of 1595 horses seen along transects on the Hale Plain during the study the activity of 1276 (80%) was recorded. Activity was not recorded for 20% of horses because they were seen during transects run primarily to determine distribution and density (chapter 5). There were 988 horses observed before they were noticeably influenced by my presence. For 319 horses no activity was recorded because they were obviously reacting to my presence and I could not be sure what they were doing before I came along. There were groups (108 horses) where activity was recorded for some individuals but not others. These horses were excluded from analyses because again I cannot be certain that they were not responding to my presence. There were 872 horses seen in groups where no members were frightened and the activity of each was recorded. Data for these horses were used to search for seasonal and diurnal changes in activity. Fifty one percent of this sample were classified according to age and 29% according to the social group they occupied. Table 3.3 shows how the transect data were sub-sampled for analyses.

Table 3.3: Sample sizes and criteria for selection of data for analyses of activity of horses seen along transects on the Hale Plain (1984 to 1986).

Number	%	Criteria	Used to determine;
1595	100	All horses seen on the Hale Plain during ground based transects	long term (1, 2 or 3 years) changes in density, distribution, body condition, social group characteristics and reproductive rate
1276	80	Activity recorded whether disturbed by me or not	the proportion of horses disturbed by me
988	62	Activity recorded before they were noticeably influenced by me	the proportion of horses not disturbed by me
872	55	Activity recorded for all members of the social group before being disturbed by me	long term and diurnal changes in activity
443	28	As above but also classified according to age (Juvenile, Sub-adult or Adult)	differences in activity between age classes
256	16	As above but also members of groups where all individuals were classified according to age and all adults were classified according to sex	differences in activity of adults in different social groups

a) Seasonal differences

There was a significant difference between periods of the study in the activity of horses seen along transects on the Hale Plain (χ^2=78, df=18, P<0.0001). Much of the difference was due to records for 3 of the 7 periods (June to August 1984, June to August 1985 and September to November 1986) (Figure 3.6). In June to August 1984 there was a much higher than expected proportion of horses seen grazing, which contrasted greatly with the very low proportion of horses seen grazing one year later when 90% of the horses were seen walking or drinking. In the period from September

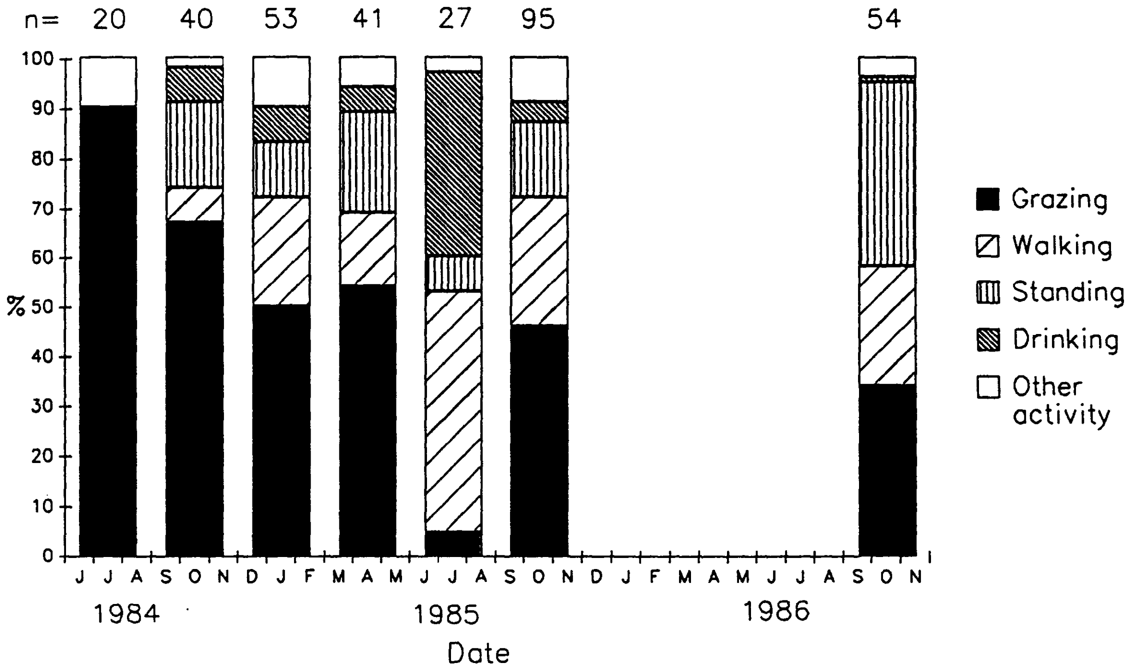

Figure 3.6: Activity of adult horses seen along transects throughout daylight hours on the Hale Plain during the study. Number of horses seen during each sample period are shown. Columns represent totals for 3 months.

to October 1986 a greater proportion of horses than expected were seen standing (i.e. resting). Figure 3.6 shows a marked decline in the proportion of adult horses seen grazing along transects from July 1984 to July 1985.

b) Diurnal pattern

The activities of adult horses differed significantly between periods of the day as shown in Figure 3.7 (χ^2=37, df=9, P<0.0001). The activities that generally occur near watering points (drinking, fighting, galloping and trotting) were combined for statistical analysis. Adult horses appear to spend a greater proportion of time grazing in the early morning and least from 1200 to 1600 hours. They are more likely to be seen walking to or from water or drinking in the afternoon than the morning and less likely to be seen standing in the early evening (Figure 3.7). The more detailed look at diurnal activity patterns presented in section 3.3.1.b) confirmed this.

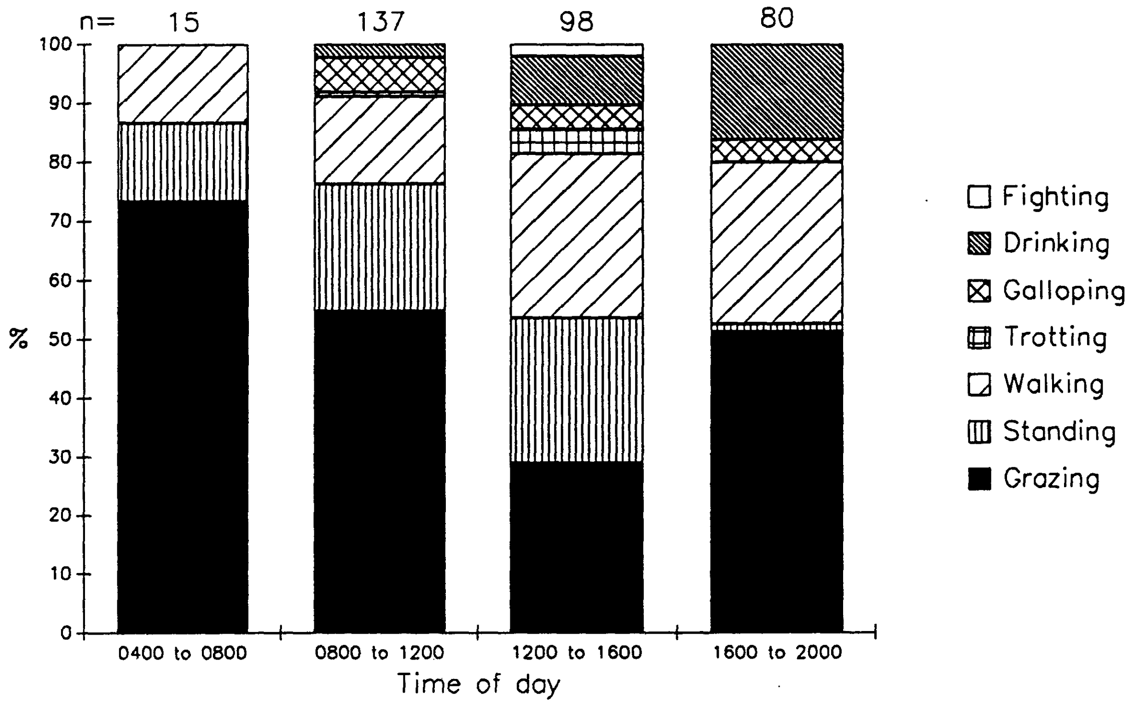

Figure 3.7: Activity of adult horses (n) seen along transects on the Hale Plain during each 4 hour period. Drinking, fighting, galloping and trotting were combined for analysis (χ^2=37, df=9, P<0.0001).

c) Age, sex and social differences

The difference between activities of juveniles, sub-adults and adults was not quite significant at the 5% level (χ^2=15, df=8, P<0.07, galloping and trotting were combined and lying and standing combined for analysis). Figure 3.8 indicates, however, that adult horses are less likely to be seen lying, galloping or drinking than younger horses, but are more likely to be seen grazing. Adults and juveniles appear to walk more than sub-adults. Bachelor males appear to walk and drink less than harem male and female adults and they graze, trot and gallop more often (Figure 3.9).

d) Bias

Figure 3.8 shows the percentage of horses seen grazing for "all ages combined" was greater than for any age-class alone. This anomaly may arise because it is easier to classify horses according to age when they are not grazing. When horses are not grazing

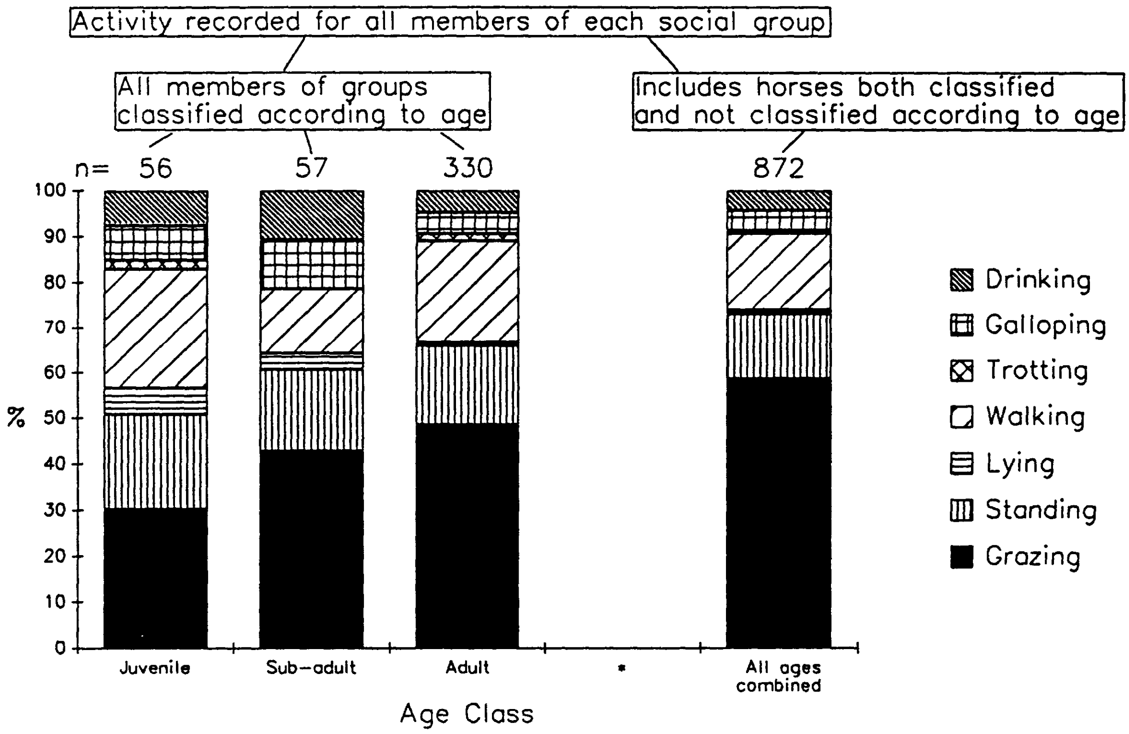

Figure 3.8: Activity of horses seen along Hale Plain transects. Number (n) of horses seen in each age class are shown.

they are more likely to be interacting with other horses and therefore display mature or immature postures. While grazing, classification of horses into age classes can be based only on body size and shape. Furthermore horses that were close or visible enough to be classified according to age may have been disturbed by my presence more so than those further away or obscured by hills or trees.

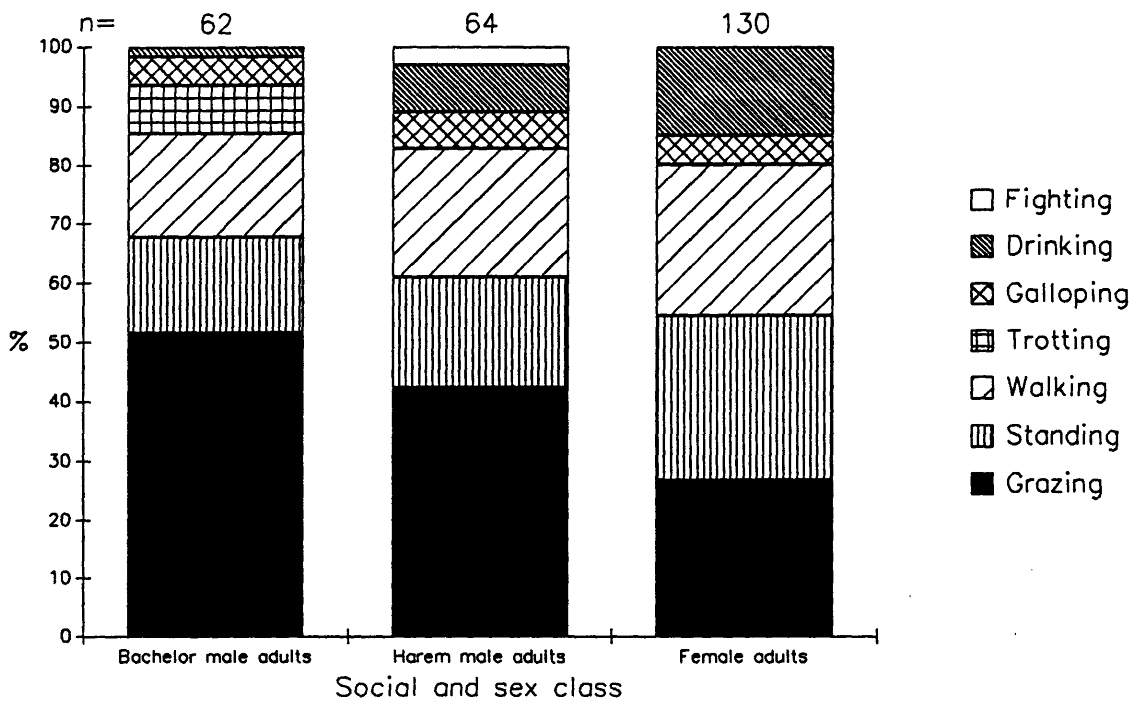

Figure 3.9: Activity of adult horses (n) seen along transects on the Hale Plain for each social and sex class. Fight and drink, gallop and trot were combined for analysis (χ^2=26, df=8, P<0.001).

3.4 Discussion

Considerable effort went into determining suitable methods for collection of data for this chapter. The use of a pocket computer, ridden horses and the technique for darting horses at watering points were all important parts of my strategy. Techniques learnt were applied during a study of home range and movement of feral horses in the Porter's Well area (Dobbie & Berman, 1990).

Unless the population is sampled adequately by transect over its entire range the proportion of horses seen at any one activity cannot be used with much confidence to estimate the time spent by individual horses at that particular activity. The transect data merely tell us what horses were doing in the area covered by transects. The apparent seasonal change in the time spent grazing in 1985 may be due at least in part to inadequate transect coverage. The population was, however, adequately sampled by transect in early 1984 and late 1986 when most horses appeared to be in the area covered by transects. The fact that transects were run only during the daylight hours does not seem important because direct observation indicated there was no difference between nocturnal and diurnal activities of feral horses. I am confident that the data recorded by direct observation can be used to estimate the proportion of time spent at any one activity.

It will be seen in later chapters (4 & 5) how changes in pasture quality and quantity were induced by rainfall and grazing. These changes in pasture then influenced the diet and habitat use of horses on the Hale Plain. In June to August 1984 there was sparse but palatable dry forage on the Hale Plain and 90% of horses were recorded as grazing. Following this there was a gradual depletion of palatable forage on the plains and terraces close to water (Chapter 4). Horses began to graze in the hills, moving further from water and outside the area covered by transects. Consequently there was a decrease in the density of horses on the plain (Chapter 5) and a corresponding decrease in the proportion of horses seen grazing along transects. Rain in spring 1985 resulted in some germination and growth of grass on the plain (Chapter 4). For a short time after this rain-induced growth event some of the horse population returned from the hills to use feeding areas on the plain. During this period, based on direct observation of a group on the flats near Top Bore in November 1985, adult horses spent between 71% and 81% of their time grazing. Similar results were obtained in March 1986 (73-77%) for a group observed in the hills and in August 1986 (74-81%) for a group on the plains after the winter rainfall and pasture growth. These data indicate there was very little seasonal change in the time spent grazing by horses on the Hale Plain.

Feeding was the major activity recorded for feral horses during my study. Estimates of the proportion of time spent grazing were mainly between 70 and 80%. This is similar to results for horses in north-west Nevada (USA) (Berger, 1986) and western Alberta (Canada) (Salter & Hudson, 1979) and Poland (Kownacki et al. 1978) but higher than for studies on Assateague Island (off the north-east coast of North America) (Keiper

& Keenan, 1980) and in the Camargue (France) (Duncan, 1980). However, I am cautious when comparing results with other studies because of the great variation in methods used and the fact that few studies cover both nocturnal and diurnal activity. Although there was no diurnal-nocturnal difference recorded in my study there may be differences for horses in other climates.

The large proportion of horses seen standing, resting and not feeding in October and November 1986 may reflect the ease with which they could fill their stomachs with high quality pasture. At that time no horses were observed in the hills and the density of horses along transects indicated most had returned from the hills to graze closer to water where there was abundant green pasture. Unfortunately there was no direct observation of horses at night during October/November to confirm there had been an overall reduction in the time spent grazing. The surprisingly low proportion (33%) of horses seen grazing along transects in October/November 1986 may have been due to them grazing predominantly at night in response to thermoregulatory needs (Belovsky, 1981) or avoidance of insects (Berger, 1986). However, there was no increase in the proportion of horses standing in the shade nor did there appear to be obvious irritation from insects. In my opinion low grazing time was a response to increased pasture quality and quantity (see Chapter 4 for description of changes in pasture). This needs verification by direct observation of feral horses during both night and day when preferred pasture is plentiful and green.

Based on data from transects I conclude the proportion of day time spent grazing by horses on the Hale Plain may range from 90% when pasture is dry and sparse to 33% when pasture is green and abundant. These results match closely those of Berger (1986) who found horses in north-west Nevada (USA) to graze for 35% of their time during summer days and 84% during winter days. In my opinion neither insects nor thermoregulation caused horses to spend less time grazing during my study but forage abundance did. Horses in a stable with a continuous supply of pelleted ration spent 38% of their time feeding (Ralston et al., 1979) a remarkably similar result to horses in summer in Nevada (Berger, 1986) and after rain in spring in central Australia.

Horses graze while travelling from water to feeding areas (i.e. where most of the feeding is done). One group of horses ("Bay Brumby's") observed to walk to water from a feeding area did not pause to graze. However, members of the group grazed as they travelled back out from water to the feeding area. Their rate of travel while grazing was about 3 km per hour. When they had returned to approximately the position they had been previously feeding (feeding area) they slowed their rate of travel. At that place, at that distance from water, presumably the density of suitable forage was adequate to satisfy their present needs. Dobbie and Berman (1990) found the core area of the home range of feral horses to be centred approximately 3 km from permanent drinking water. Most of a horse's time is spent in the feeding area (core area of the home range) with relatively infrequent excursions to the drinking place. If pasture in a feeding area is not replenished by growth or germination after rainfall then horses presumably move to another feeding area searching for a higher density of suitable forage. Such a place is most likely to be further from drinking water.

Dobbie followed a group of radio-marked horses continuously for 48 hours without them going to drink (Dobbie & Berman, 1990) and my data indicated that horses are commonly away from water for periods greater than 30 hours. A drinking frequency of once every 30 to 48 hours is consistent with findings for other free-roaming horses that need to walk several kilometres from water to feed. Horses in the Pryor Mountains USA returned to drink once each day (Feist, 1971) and others in western Nevada visited water as little as every second day (Pellegrini, 1971). Cattle in central Australia also have a similar frequency of drinking to feral horses (Squires, 1981). Although I have no data for central Australian horses drinking frequency would almost certainly vary with temperature, pasture quality and the proximity of water to feeding areas. When water is easy to obtain horses may drink small amounts several times a day (Waring, 1983).

3.5 Conclusions

Feral horses in central Australia spent most of their time foraging. There was no difference between sampled nocturnal and diurnal time-budgets. However, horses were more likely to be seen walking to water and drinking in the afternoon or evening than at any other time of the day. The proportion of time spent grazing did not appear to vary seasonally. Nevertheless, when forage was green and abundant the number of horses seen grazing during the day was markedly lower than when forage was dry and sparse.

A greater proportion of bachelors were seen grazing than harem stallions or mares. More harem stallions were seen fighting than bachelors. Mares and their accompanying stallions were seen walking or drinking more often than bachelors, perhaps because of the water requirements of lactation. With a reduced need to fight and travel to water bachelors may have a feeding advantage over harem stallions.

CHAPTER 4
RESOURCES FOR CATTLE AND HORSES

4.1 Introduction

The main resources required by cattle and horses in central Australia are water and plants. Plants provide food, shade and protection from men in helicopters. Many factors (e.g. fire), including horses and cattle, influence the vegetation and surface water of arid central Australia. However, I believe the overriding influence is rainfall.

The rainfall pattern of the last 115 years indicates the irregularity of this aspect of the climate (Figure 1.3). During good seasons after a period of high rainfall the cattle-carrying capacity of central Australian stations appears unlimited, contrasting greatly with the periods of severe drought which Griffin and Friedel (1985) stated had occurred for at least 20 years out of the last 100. Such unpredictibility is a characteristic of arid areas. However, variability in effective precipitation in Australia and southern Africa is higher than anywhere else in the world due to high evaporative demand (McMahon et al., 1987). If rainfall is the overriding influence on resources, then it is also likely to be the overriding influence on all other aspects of feral horse ecology.

Chapter 3 shows that feral horses in central Australia spend most of their time eating. They appear to spend more time at this activity than cattle (Low et al., 1980 & Chapter 10). What are they eating? Are they eating the same species of plants as cattle? Cattle spend time ruminating. Horses do not ruminate. Do horses use the extra grazing time to be more selective?

In this chapter I firstly describe changes that occurred to the quality and quantity of pasture and identify important factors that determined these changes. Secondly I look at the diets of horses and cattle and thirdly I describe the types of drinking places that are available and the factors that determined differences in their use by horses and cattle. Finally other resources, shade, mates and habitat required for avoidance of predators are metioned briefly.

4.2 Methods

4.2.1 Definition of types of plants

Shrubs (<2 m tall) and trees (>2 m) are woody, dicot plants. They are called perennial plants because they have the potential to flower and seed many times between germination and death. For herbaceous dicot plants (forbs) and monocots (grasses) there is a continuum of life forms ranging from ephemeral (short-lived), to perennial (long-lived) plants. In central Australia the variable climate makes classification of plants into life form categories difficult. With a run of good rainfall periods annuals can behave as perennials or alternatively during poor years perennials can behave as annuals. The term short-lived perennial is sometimes used to describe annuals that tend towards a perennial existence. For the purposes of this thesis I have confined myself to the use of two terms, annual and perennial, to describe life forms of grasses and forbs. Annuals are defined here as being plants that usually germinate from seed when conditions are suitable and complete their life cycle (germination, growth, flowering, seeding and death) in one year or less. All the rest are perennials.

4.2.2 Rainfall

In the introduction above I emphasised the importance of rainfall as a factor influencing the food and water of horses and cattle in central Australia. I have found the Cumulative Rainfall Residual curve (CRR or CUSUM curve) (Foley, 1957) a valuable technique for illustration of changes in the amount and timing of rainfall (Figure 4.1). When a month has rainfall below the mean the CUSUM curve descends. It ascends during above average months. The steeper the slope the greater the difference between the mean and actual rainfall. That is, a very steep negative slope for a long period indicates a very dry period relative to other periods along the curve. Figure 4.1 indicates the dryness of most of my study period (March 1984 to November 1986 and 1988) compared to 1983 and January 1984 and indicates the relative importance of the rainfall of winter 1986. I use sections of the Figure 4.1 CUSUM curve that correspond with periods of vegetation and diet sampling to illustrate the influence or lack of influence of rainfall. I combine the CUSUM curve with a conventional rainfall histogram. The histogram shows how much and when rain fell and the CUSUM indicates the cumulative difference between the mean and actual rainfall. Rainfall data for The Garden Station were obtained from the Bureau of Meteorology (B. Met.).

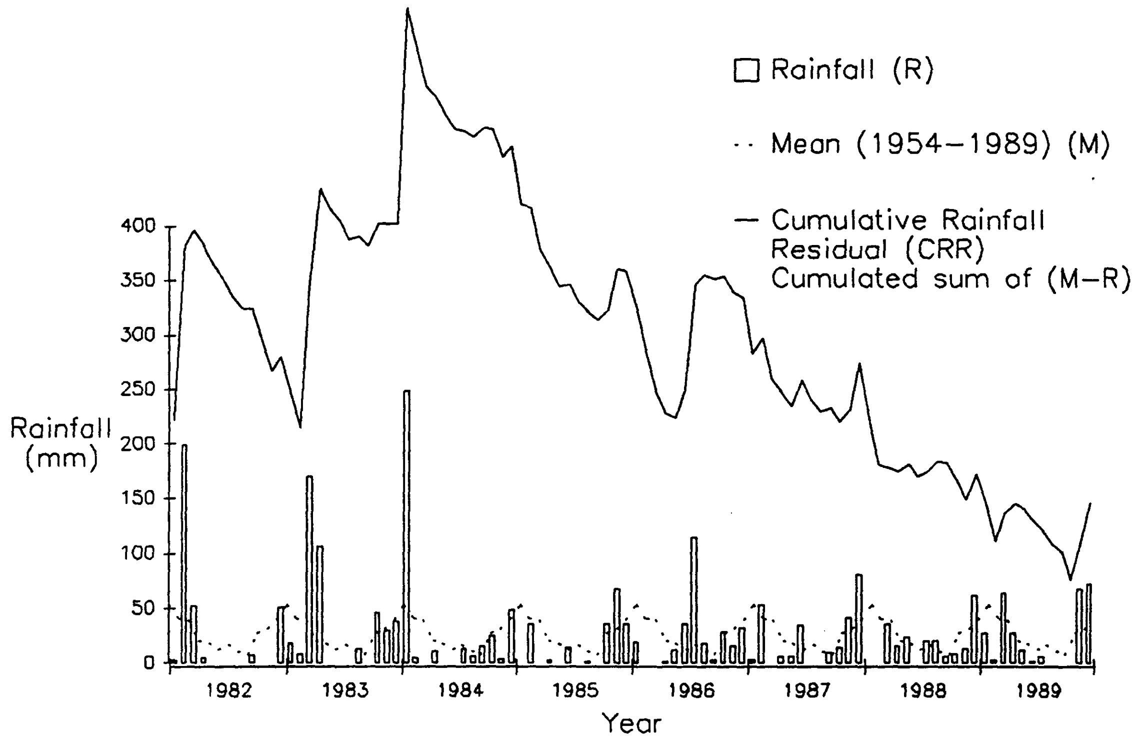

Figure 4.1: Shown is the long-term mean and actual monthly rainfall for The Garden station homestead (B. Met.) along with the CUSUM curve (CRR) which indicates the rainfall since 1984 has been consistently below the mean.

Fortunately, during this project the Garden Station experienced a period following a high summer rainfall (1984), a long period (27 months) with very little rain and a period of high winter rainfall (winter 1986). This provided me with the opportunity to sample the available vegetation and diet of horses and cattle under a variety of conditions from wet to dry, summer rains and winter rains.

Alice Springs Post Office rainfall figures show that 51% of summers have had less rainfall than 1982/83 and 1983/84 and only 2 winters since 1874 have had more rainfall than winter 1986. This indicates that a summer rainfall event such as those in 1982/83 and 1983/84 is not unusual, whereas winter 1986 was unusually wet. However, I believe the state of the vegetation at any particular time depends not only on the previous summer or winter rainfall but on a sequence of rainfall events leading up to the present time. The summers of 1982/83 and 1983/84 were the only two consecutive summers on record both with rainfall greater than 350 mm (Alice Springs Post Office 115 years) indicating that plants that germinate and grow as a result of summer rain may never have been more abundant than at the start of this project.

4.2.3 Pasture quality and quantity

Section 2.2.2 describes in detail the methods used to monitor changes that occurred in the quality and quantity of pasture on the Hale Plain during the study. Quality is a measure of the food value of pasture. Green pasture generally has higher food value, particularly protein content, than dry pasture. Quality also varies between species, some having higher food value than others (at the same growth stages) (Table 4.1).

I used quick methods to assess a large number of vegetation sites for pasture quality and quantity while recording stock distribution along driven transects and I supported these quick methods by more intense sampling at a limited number of sites (see section 2.2.2). The quantity of pasture was estimated as biomass (g/m^2) or as the proportion of points that hit vegetation during wheel-point transects. The quality was determined by estimating the proportion of green to dry pasture and the proportion of leaf to stem. Green leafy pasture was assumed to have higher protein content than dry and stemy pasture. Additionally, the species composition of the pasture determined by wheel-point transects allowed me to detect initial (before the pasture became too sparse) differences in pasture quality between land units, on the basis of species composition. For much of 1985 and 1986 there was insufficient time to determine species composition accurately by wheel-point transect because pasture was too sparse. Notes of the relative proportions of perennial and annual grasses, grasses and forbs were kept during periods when wheel-pointing was too time consuming. Quality scores were calculated for pasture by the method described below in this section. P.J. Jarman used this method to score the quality of diet based on the species composition of the faeces of horses and cattle (Berman & Jarman, 1987).

Table 4.1: Comparison of the crude protein content (CP) and dry matter digestibility (DMD) for 3 genera of grasses. The whole, green and flowering plants were analysed by Doug Wilson (pers. comm.).

Genus	DMD ± SD (n)	CP ± SD (n)	r^2(DMD vs CP)
Enneapogon	49 ± 8 (9)	7 ± 4 (21)	0.70*
Astrebla	42 ± 4 (30)	6 ± 2 (44)	0.41*
Aristida	34 ± 8 (19)	3 ± 1 (32)	0.48*

*P<0.05, statistically significant correlation.
n is the number of individual plants sampled.
Crude protein for *Enneapogon* and *Astrebla* did not differ significantly but that for *Aristida* was lowest.
Dry matter digestibilities differed significantly between the three genera.

Rangeland scientists have categorised the grass species of the Alice Springs district on the basis of their palatability to stock, and of their digestibility and protein content (e.g. Department of Primary Production, Central Australian Range Herbarium, Volume 1: Introduction. [1982]). On the basis of the above rating of quality of grass when green, the grass genera were classified by Jarman (Berman & Jarman, 1987) as Excellent, Good, Moderate and Poor. I used these ratings to determine the quality of available pasture in each land unit and the quality of diet (as reflected in faeces) selected by horses and cattle. For each percentage point of grass in the analysed faecal sample or in records of a wheel-point transect, a score akin to protein content of dry samples (7,5,3, or 1) was assigned. The overall score could thus range from 100 for a sample consisting entirely of Poor grass (*Aristida* spp.) to 700 for a sample consisting entirely of Excellent grass (which was represented only by *Enneapogon* spp.). A more detailed description of methods appear in section 2.2.

Table 4.1 shows the results of analysis of protein content and digestibility of three common genera collected in central Australia during the study period (data from Doug Wilson pers. comm., DPI&F). These data confirm that the system used for rating food value was appropriate for the conditions during the study. Annual grasses, of which the most common are the oat grasses (*Enneapogon* spp.), are rated as having the best food value and as expected this genus had the highest protein content and the highest digestibility of the three tested by Wilson. *Aristida* spp., which are rated as having the least food value, contained the lowest protein content and digestibility. Mitchell grasses (*Astrebla* spp.) are rated as having intermediate food value and had intermediate protein content and digestibility. Protein content correlated significantly with digestibility for all three genera. Changes in the pasture of land units dominated by these three genera are compared since they represent the range of pasture qualities with regard to species composition.

4.2.4 Diet of horses and cattle on the Hale Plain

The first objective stated on the contract that established this study was to <u>evaluate the diet of horses in selected study areas under various seasonal conditions and determine the degree of dietary overlap with cattle</u>. Faecal samples from horses and cattle were collected on the Hale Plain (1984 to 1986) by me. At the University of New England C.J. Phillips analysed these samples to determine the proportion of plant species present by identification of epidermal fragments; and P.J. Jarman and I interpreted the results, our conclusions being included in a report (Berman & Jarman, 1987) for the CCNT. The methods are described in detail in section 2.2.2 above and the results summarised in section 4.3.2 below.

4.2.5 Water

To detect differences between watering points in the number, size of type or social groups using them, information was recorded about groups of horses seen at each watering point on the Hale Plain during transect patrols (Figure 2.7). Most drinking by stock on the Hale Plain occurs at bores which are permanent supplies of water. The quality of the water at each bore is presumed good (J. Turner pers. comm.; and tasted it myself) so any differences in use of these by horses might be related to differences in the available land units close to these waters. To interpret differences if any in the use of watering points on the Hale Plain the proportion of each land unit within 3 km was determined for each watering point. The Hale Plain has a diverse range of land units from hilly and tree-covered to flat and treeless. Within the two paddocks (White Dam and Cox Bore paddocks) on the Hale Plain horses and cattle could move freely to selected pastures and both paddocks contained significant proportions of each land unit (Figure 2.7 & 2.9 & Plate 3).

In contrast the Porter's Well area differs from the Hale Plain in that the land is consistently hilly and there are many more watering points of varying permanence. On the Hale Plain I was able to look for the influence of land unit on the use of watering points. In the Porter's Well area we (Dobbie and I) looked at the influence of permanence of water on the use of watering points by horses (Dobbie & Berman, 1990).

On 25 March 1988 at the end of a very dry period a survey by helicopter of the Porter's Well study area was conducted by me to locate all important watering points. During the helicopter survey the number of horses seen at each water-hole was recorded. Information regarding the location and permanence of watering points was also provided by the pastoralist and helicopter pilot. Four days after the survey flooding rain fell causing all creeks and rivers to run, replenishing all watering points. In Alice Springs 205 mm fell in 24 hours on the 30 March. Two months after the flood (27 May) I surveyed a 7.2 km section of Trephina Creek (Figure 4.2) by foot to count potential watering points and assess their use by horses, cattle and donkeys. Activity was scored as follows: 0 - no sign, 1 - few tracks, 2 - moderate number of tracks and dung, 3 - many tracks and a few horses present, 4 - many horses present (10 - 100) and 5 - >100 horses present. The amount of horse, cattle or donkey activity was subjectively assessed and scored as above at bores and major water-holes at regular intervals during the study by Dobbie and Berman (1990). Fibreglass rods were placed in 6 of the larger watering points (shown in Figure 4.2) to measure the rate at which water disappeared due to both drinking, seepage and evaporation.

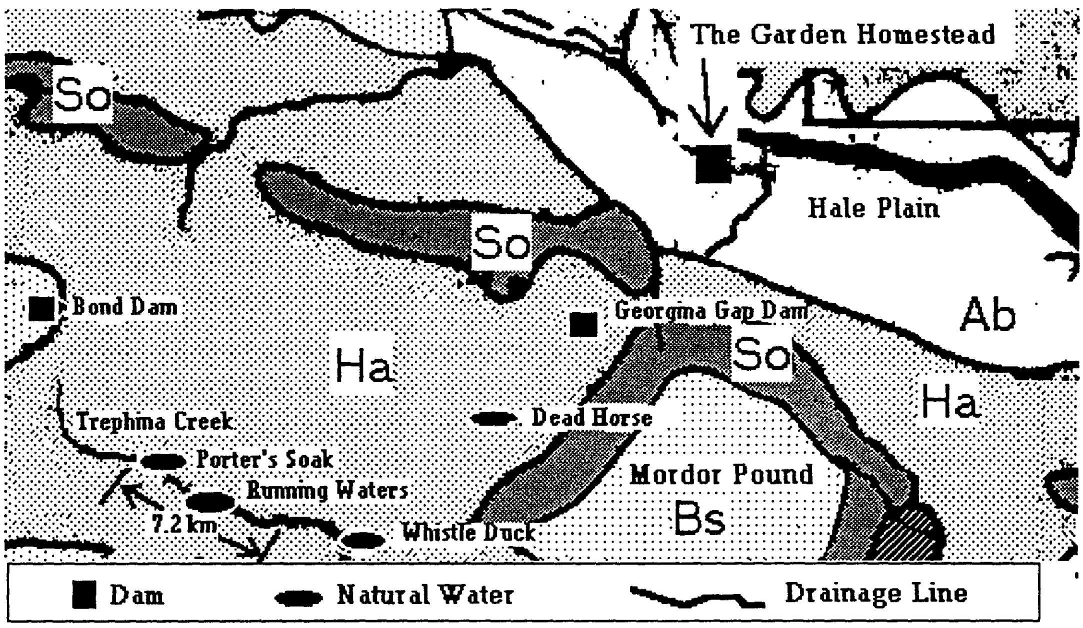

Figure 4.2: Location of survey for watering points in Trephina Creek. Perry's Land Systems (Perry et al. 1962) are shown.

Dobbie made observations at different water-holes to record information about horse groups coming in to drink (Dobbie & Berman 1990). The purpose was to determine which water-holes were of most importance to the feral horse herd. Dobbie recorded the number of horses visiting 3 water-holes by waiting and watching for 36 hours at each, consecutively. Observations began at 1900 h and finished 36 hours later at 0700 h. Dobbie then moved to the next water-hole to begin watching at 1900 h. One of these water-holes had a permanent supply of water (Porter's Soak) and the other two were temporary (Whistleduck and Dead Horse Water-holes). The temporary waters, one of which was 6 km and the other 12 km from permanent water, dry up in approximately 6 to 9 months without rain.

4.2.6 Other resources for cattle and horses

Resources for cattle and horses discussed other than food and water are shade, mates and protection from predators. The availability of trees for shade in each land unit was determined from aerial photography and the use of shade by horses and cattle was recorded during ground-based transects. The composition of each group of horses and cattle was recorded during ground based transects. This information allowed a comparison between male and female horses in the availability of mates. Dingoes probably take only sick or abandoned foals but they are accused of taking a significant number of calves. I do not regard dingo predation as important for this study so the subject is not dealt with. However, habitat choice by horses and cattle may be influenced by their need to avoid human predation.

4.3 Results

4.3.1 General description of changes in pasture during the study

After summer rain, germination and growth of pasture is rapid and many palatable annual species of grass flourish. Two good summers in a row (1982/83 and 1983/84) produced abundant annual pasture. Thus in March 1984 when this study commenced annual grasses *Enneapogon* spp. were virtually everywhere. The rainfall of spring 1984 was low and caused some germination and growth but the hot summer and lack of follow-up rain caused the new growth to dry off quickly. Better rains fell in spring 1985, but again there was no follow-up rain and pasture grew for only a limited period. By winter 1986 very little pasture growth had occurred since summer 1984 (over 2 years) and many areas were denuded, particularly areas that normally grow only annual grasses (units C). Very old clumps of perennial grass remained in other areas (units D,G,and F) and annual grasses were available only in hills of land unit B (see Chapter 2, Plate 3 and Figure 2.9).

Rainfall during winter is uncommon in central Australia and causes germination of many plants that are rarely seen. Most of the plants that germinated after the 1986 winter rainfall were non-grasses. The alluvial areas were a sea of yellow daisies and purple flowered vetch (*Swainsona* spp.). Perennial grasses grew slowly providing increased amount of pasture for stock but the supply of annual grass was not replenished because these grasses require summer rainfall to germinate.

4.3.2 Pasture quality and quantity

a) Quantity of pasture

Sites varied in pasture (dry weight) biomass from 0 to 400 g/m^2. Alluvial sites (unit D) had the highest biomass in areas dominated by *Eulalia fulva*, *Bothriochloa ewartiana* and *Enteropogon ramosus*, and the lowest biomass on scalded areas. Areas dominated

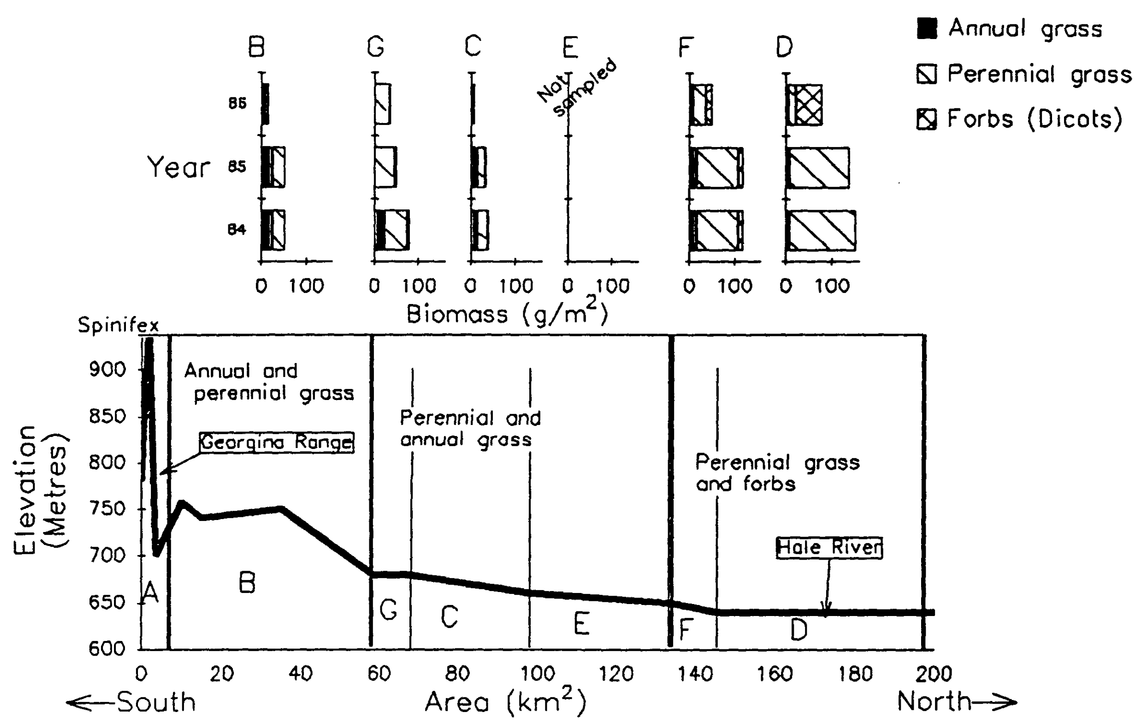

Figure 4.3: Shows change in mean biomass of dry pasture for land units on the Hale Plane (1984-86). The idealised cross-section (thick line) (S-N) shows cumulative area, elevation and a generalised description of types of plants.

by annual grasses (unit C) had much less pasture biomass than those dominated by the generally less palatable perennial grasses (units D, F and G). The mean biomass of pasture for all sites and all sampling periods combined was 59 g/m^2. During the study the mean biomass of pasture for all units decreased (see Figure 4.3). Figure 4.3 shows the changes in the proportions of perennial, and annual grasses and forbs during the study (data from 52 sites combined). It also indicates differences between the land units in biomass and dominant types of pasture plants.

For unit C the mean biomass of pasture dropped 84% in 2 years and there was no increase brought about by the 1986 winter rainfall (Figure 4.4). The biomass of unit D decreased 63% in 2 years then increased in response to the 1986 winter rainfall. The rise from a mean of 55 g/m^2 to 73 g/m$_2$ perhaps underestimates the amount of biomass of non-grass material that germinated in unit D after the rain of winter 1986. At that time as well as growth of perennial grasses there was abundant germination of daisies

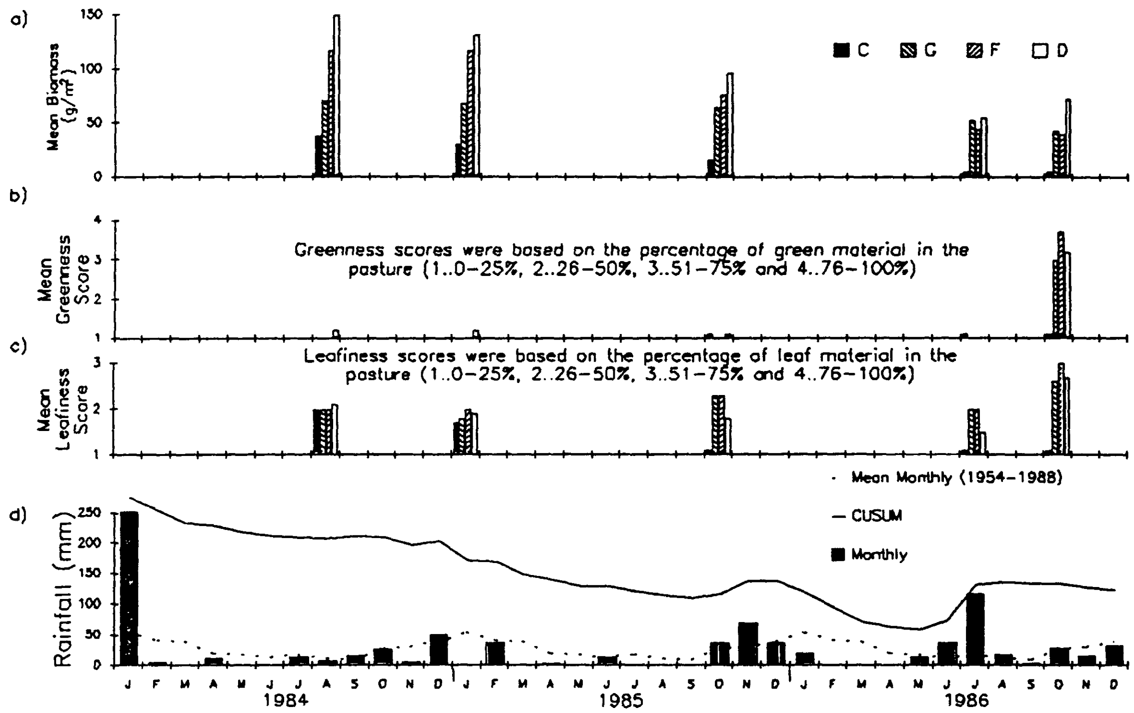

Figure 4.4: Change in mean biomass a), greenness b) and leafiness c) for Hale Plain land units. The units are in order from high (C) to low (D) on the catena (Figure 4.3). The rainfall is shown in d).

(*Helichrysum* spp.), and vetch (*Swainsona microphylla* and *Swainsona aroboides*). Although not all *Swainsona* spp. are toxic it is important to note that they grew only in unit D.

The pasture of unit F has a very small annual component and remained relatively stable throughout the study. However, some sites in the vicinity of Cox Bore lost a considerable amount of biomass causing the mean biomass to drop 66%. Section 4.3.2.d) presents data on the relationship between distance from water and pasture removal.

Unit G appeared to maintain relatively constant mean biomass during the study period (dropped 39%). However, the pasture of unit G is composed of Mitchell grass (*Astrebla* spp.) which is a rather coarse, tussock-forming perennial and some shorter annual species (*Enneapogon* spp.) and the tiny perennial called five minute grass (*Tripogon loliiformis*). The annual portion of the pasture of unit G disappeared at a rate

Table 4.2: Vegetation of land units B,C,D,F and G on the Hale Plain in 1984. Pasture was too sparse and time too short to determine species composition during most of 1985 and 1986 (mean ±SD are shown).

Land Unit	B	C	D	F	G
Sites (n)	2	14	6	2	3
Quality score	579	608	143	359	409
Quantity (g/m^2)	58 ±13	38 ±12	149 ±113	117 ±61	71 ±17
Perennial(%)	24 ± 7	23 ±15	95 ±46	90 ±28	73 ±27
Annual(%)	71 ±19	62 ±31	5 ± 8	0	15 ± 4
Forbs(%)	5 ± 2	15 ±12	0	10 ± 3	12 ± 4
(Trees/ha)	26 ±10	6 ± 3	16 ± 5	0	5 ± 3

similar to that of the grasses of unit C while the Mitchell grass remained.

b) Quality of pasture

In 1984 the wheel-point transects were used to estimate the species composition of the pasture in land units B,C,D,F and G. The food value of each land unit was then calculated using the same scoring system used for determination of diet quality (section 4.2.3 above). Table 4.2 shows that units B and C had the highest food quality determined by the relative proportions of grass genera.

Photographs and field notes recorded increases in quality (greenness and leafiness) in December 1984, more so in October 1985 and most notably after the winter rains of 1986. These increases were due to germination and growth after rainfall (Figure 4.4). Decreases in quality occurred soon after the rainfall of both spring 1985 and summer 1986 because there was no follow-up rain and the weather was hot and dry. The rainfall of winter 1986 caused the most significant and long-lasting increase in pasture quality.

The amount of green material in the pasture was low (less than 25%) for most sites

Table 4.3: Vegetation within 3 km of watering points (Figure 2.7) on the Hale Plain in 1984 based on information from Table 2 and estimates of the proportion of each land unit within 3 km of each watering point.

Paddock	White Dam		Cox Bore	
Watering point	White Dam	Gidyea Bore	Top Bore	Cox Bore
Quality score	477	344	356	220
Quantity (g/m^2)	74	103	101	132
Perennial (%)	69	74	71	89
Annual (%)	35	30	34	13
Forbs (%)	11	5	5	3
(Trees/ha)	7	15	16	14

throughout the study period (Figure 4.4). Significant increases in the greenness of pasture occurred only after the rain of winter 1986. Very little germination and growth (i.e. production of green material) occurred in sites of unit C even after the winter rainfall of 1986.

Reduction of the mean proportion of leaf material occurred for sites of units C and D during the first 2 years of the study (Figure 4.4). Slight increases in October 1985 for units F and G were due to growth in gilgais after the spring rainfall of 1985. The mean leaf/stem ratio increased for D, F and G but not C after the winter rainfall of 1986.

c) Rainfall, grazing, quality and quantity correlation

Biomass of pasture (for 52 sites, all land units combined) was negatively related to time since the last major summer rainfall (i.e. January 1984) ($r=-0.17$, $n=52$, $P<0.05$). Figure 4.4 shows that the rainfall of winter 1986 did not promote pasture growth sufficient to compensate for reduction in biomass during the prior 2 years of dry weather. There was no significant correlation between the time since the last rainfall (of any amount) and pasture biomass ($r=-0.01$, $n=52$, NS). Minor periods of rainfall therefore appear to exerted little influence on biomass compared to major periods of rainfall (summer 1983/84 and winter 1986) particularly summer rainfall.

There was a positive association between the proportion of plants grazed and time since the last major rainfall period ($r=0.67$, $n=52$, $P<0.001$). In other words, as time progressed from the last major rainfall period the proportion of plants that were recorded as having been grazed increased.

Both greenness and leafiness of pasture were higher in October 1986 than it was at any other time during the study (Figure 4.4). Minor periods of rainfall appeared to have little influence on pasture quality when compared to the winter rainfall of 1986.

The proportion of pasture plants that had been grazed was negatively correlated with greenness, leafiness and the biomass of pasture (Table 4.4). The negative correlation between distance from watering point and greenness indicated that sites with the highest proportion of green material were generally closer to watering points than other sites. The association between distance from water and proportion grazed was negative however, but not statistically significant. A similar insignificant negative result occurred for distance from water and biomass. The fact that there is considerable variation in biomass within and between units may make relationships unclear at this level of analysis. Also more sites dominated by unpalatable grasses happen to be closer to water than sites with palatable grasses.

d) Quantity, distance from water and dominant grasses

Figure 4.5 shows relationships between distance from water and cover for 5 sites dominated by *Enneapogon* spp. (excellent food quality) and 5 dominated by *Astrebla* spp. (moderate quality) sampled in October 1984. For the 5 sites dominated by *Aristida browniana* (poor quality) there was no relationship between distance from water and cover in October 1984 or in June 1985. Neat the *Astrebla* site 6 km from permanent water a storm filled gilgais with water and allowed heavy grazing by cattle to occur there. These results show the importance of ephemeral waters in extending the grazing radius

Table 4.4: Results for linear correlation analysis of pasture grass quality, quantity and grazing. Presented are the correlation coefficients and the level of significance.

	% Grazed	Biomass	Greenness	Leafiness
Distance from water	-0.11	-0.04	-0.17*	0.00
% Grazed	-	-0.33***	-0.50***	-0.59***
Biomass	-	-	-0.06	0.27***
Greenness	-	-	-	0.66***
***P<0.001, **P<0.01, *P<0.05 and others were not significant				

of stock. Data for the *Astrebla* site 6 km from permanent water were excluded from the regressions since I was looking for the influence of permanent water not ephemeral on quantity of pasture. For both pastures dominated by *Enneapogon* and *Astrebla* there is a relationship between distance from permanent water and arcsine percent cover. The relationship does not appear linear so I fitted polynomial curves (power 3) to data for *Enneapogon* and *Astrebla*. I believe all pasture grazed by horses and cattle may fit a curve like that shown for *Enneapogon* and I suspect the *Astrebla* sites did not cover a great enough distance from water for me to obtain the complete curve. There was no relationship between distance from water and arcsine cover for *Aristida* pasture. Again I may have only sampled part of the curve. Being relatively unpalatable pasture the steep section of the curve may be within 1 km of water. This interpretation is supported by general observations.

In summary Figure 4.5 shows below average rainfall, closeness to water and high quality pasture species to be associated with low pasture quantity (see also Plate 5). However, 5 sites is a very small sample size and, as was seen with the *Astrebla* pasture, ephemeral water and patchy rainfall can influence results dramatically. The following section describes results of further work to check the relationship between distance from water and pasture.

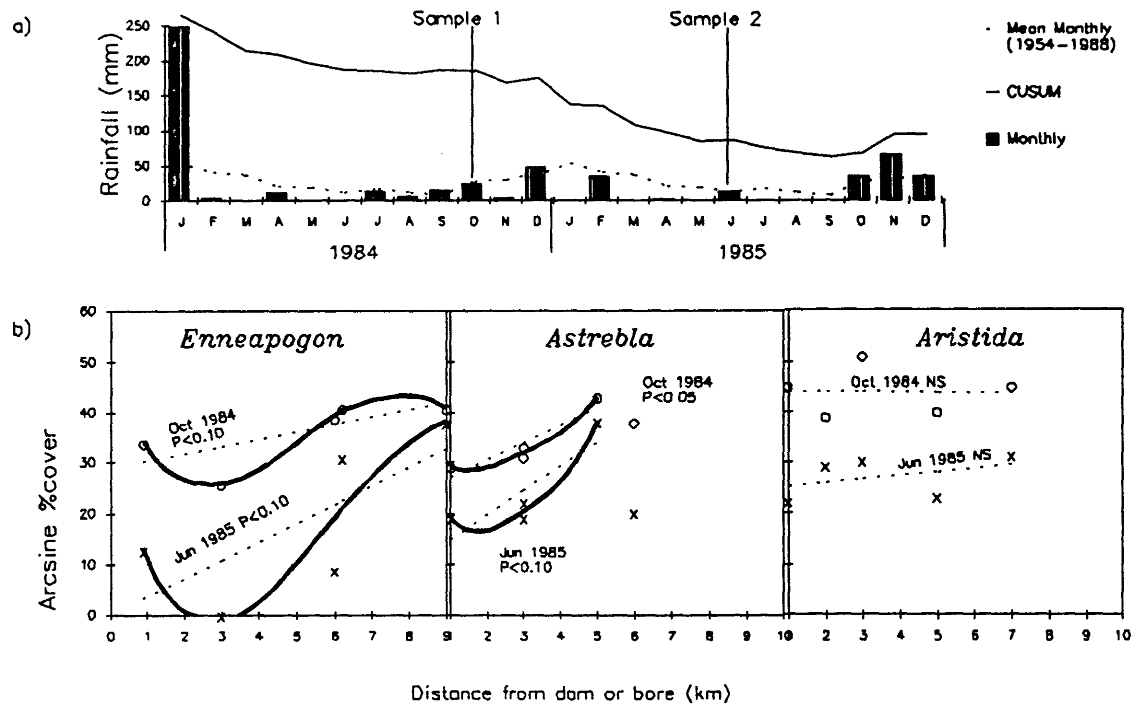

Figure 4.5: a) Rainfall 1984-1985 and b) Arcsine cover and distance to water for *Enneapogon* (excellent food), *Astrebla* (moderate food) and *Aristida* (poor food).

e) Annual pasture cover (quantity) and distance from water

Data collected by wheel-point transects at twelve sites representing Grant's land unit 5.1 indicated that there was a linear relationship ($r=0.61$, $P<0.05$) between percent cover and distance from permanent water in October 1984 (Figure 4.6). Two of the twelve sites were 0.9 km from substantial ephemeral water-holes and were found to have less cover than expected when measuring distance from permanent water. Using distance from the nearest watering point instead of distance from permanent water improved the correlation coefficient ($r=0.87$, $P<0.001$) of the regression. A watering point was defined as one that held water for more than 3 weeks since the last significant rainfall. By November 1985 all sites had much reduced cover and there was no longer a significant correlation between distance from water and cover. Sites between 3 and 4 kilometres

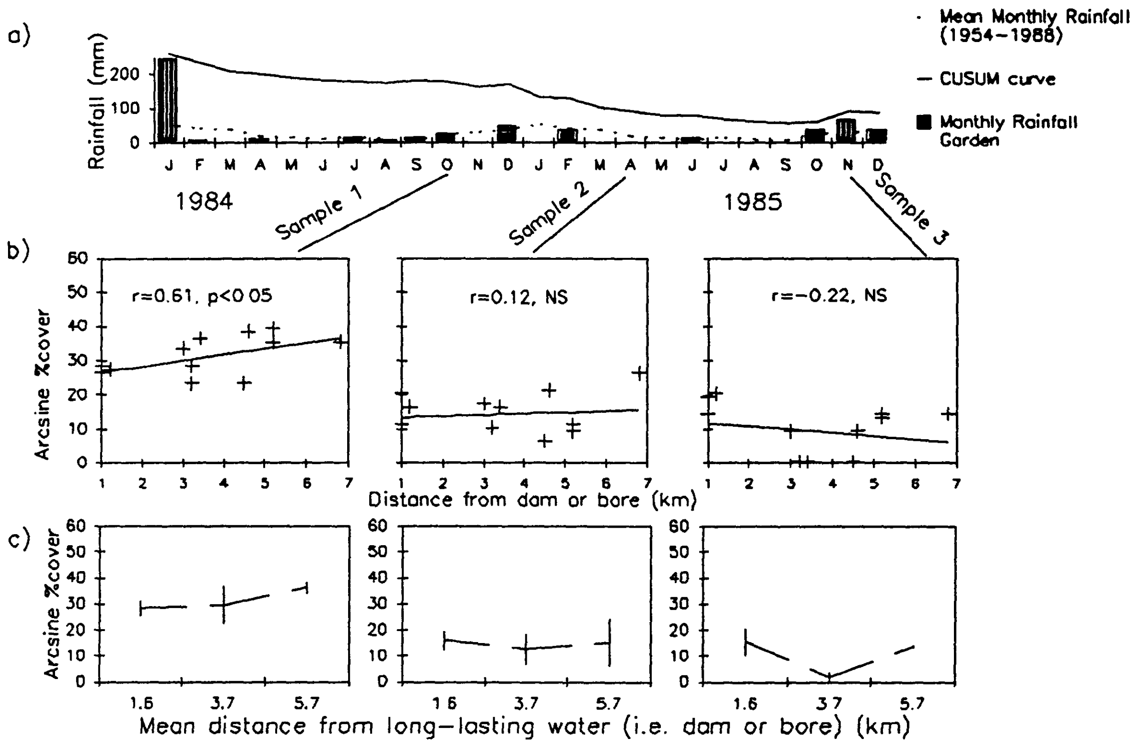

Figure 4.6: a) Rainfall from 1984-1986. b) Cover and distance to dam or bore for 12 sites representing Grant's land unit 5.1, *Enneapogon* spp.. c) shows mean cover ± SD.

from water appeared to have lost pasture more quickly than sites closer to or further from permanent water (Figure 4.6) during the period from October 1984 to November 1985. Calculating and plotting the mean percent cover for sites grouped (dist<=3 km, 3<dist<=5 km and dist>5 km) with respect to distance from permanent water illustrates the apparently more rapid reduction in cover between 3 and 4 kilometres (Figure 4.6).

Plate 5: Change in pasture during the study period at a site (a,c,e & g) initially dominated by *Enneapogon* 6 km from permanent water and a site (b,d,f & h) initially dominated by *Aristida* 0.9 km from permanent water. Horses were responsible for removal of vegetation from the *Enneapogon* site and cattle for the *Aristida* site. Photos (a & b) were taken in August 1984, (c & d) June 1985, (e & f) December 1985 and (g & h) in October 1986.

4.3.3 Diet of horses and cattle

Most of this section is taken from our (C.M. Phillips, P.J. Jarman and me) report on the diet of horses and cattle prepared for the CCNT (Berman & Jarman, 1987). In that report we aimed to determine the degree of dietary overlap between horses and cattle. I suspect food availability to be the main driving force behind changes in other aspects of the ecology of central Australian feral horses so this section is crucial. The ability of horses to obtain an adequate diet may influence their activity patterns, habitat use, social organisation, and population dynamics.

a) Faecal samples

Over 250 faecal samples were analysed. It nearly always proved easier to find fresh faeces of cattle than of horses near bores. In the later samples, collected specifically for detailed comparisons, twice as many cattle as horse faeces were sampled.

b) Numbers of grass species

I collected 39 species of grasses in the study area. These are listed in Appendix III. A further 4 monocot species were found by C.M. Phillips in small quantities in analysed faeces of horses and cattle and had sufficiently characteristic epidermal features to label them Unknown Species A to D. Horses and cattle were each recorded as having eaten 35 species. Their known-to-be-eaten lists differed very little. Cattle were not detected eating *Aristida nitidula, Enneapogon cylindricus* and *Panicum decompositum*. Horses were not detected eating *Aristida inaequiglumis, Digitaria coenicola*, and Unknown Species D. None of these plants was a frequent component of the other animal's diet. The known species are not abundant in the study area.

Despite this similarity in their total lists of eaten species, and in their most commonly and abundantly eaten grass species, horses and cattle tended to differ in the numbers of grass species detected in their faeces from any one place and time. This is illustrated in Figure 4.7. In 12 matched samples (that is, matched for collection site and date, and for number of analysed faecal samples from each species), cattle had eaten detectably fewer

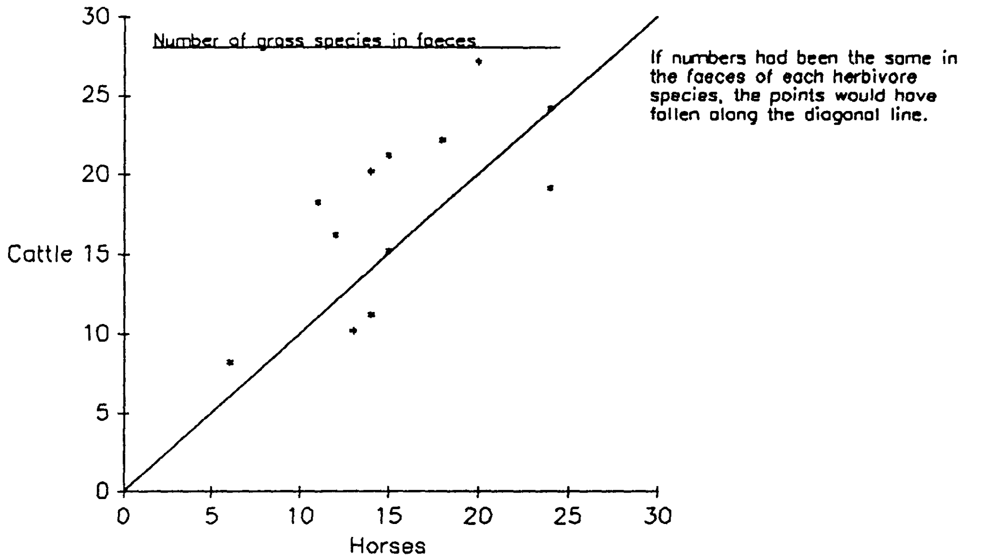

Figure 4.7: The number of grass species identified in faeces of cattle and horses on the Hale Plain. Samples were matched for place and date of collection. Taken from Berman and Jarman (1987).

grass species than horses in three, as many as in two, and more than horses in the remaining seven collections.

c) Monocot:Dicot ratio

The coarsest level of analysis recorded the ratio of fragments of monocots and dicots in the faecal samples. Both horses and cattle took mainly grasses but also ate some dicot (non-grass) plants. Dicot species formed between 17 and 51% of the fragments in cattle faeces, and between 8 and 28% in horse faeces. When the proportions of monocot fragments in the faeces of horses and cattle feeding in the same paddock in the same season are compared (Figure 4.8), horses always averaged a higher proportion of monocot fragments than cattle. There were seasonal changes in the monocot : dicot ratio for both cattle and feral horses (Figure 4.9). Soon after rain had induced pasture growth, horse faeces contained low proportions of dicot fragments; those proportions tended to increase with time since rain, reaching their highest levels in June and July 1985. Cattle followed a similar trend, but their response to the summer rains in 1985/6 may have been delayed compared with that of horses. There was a significant (r=0.62, df=11, P<0.05) correlation between percentage of monocot fragments in the faeces of cattle and horses sampled at the same sites and times.

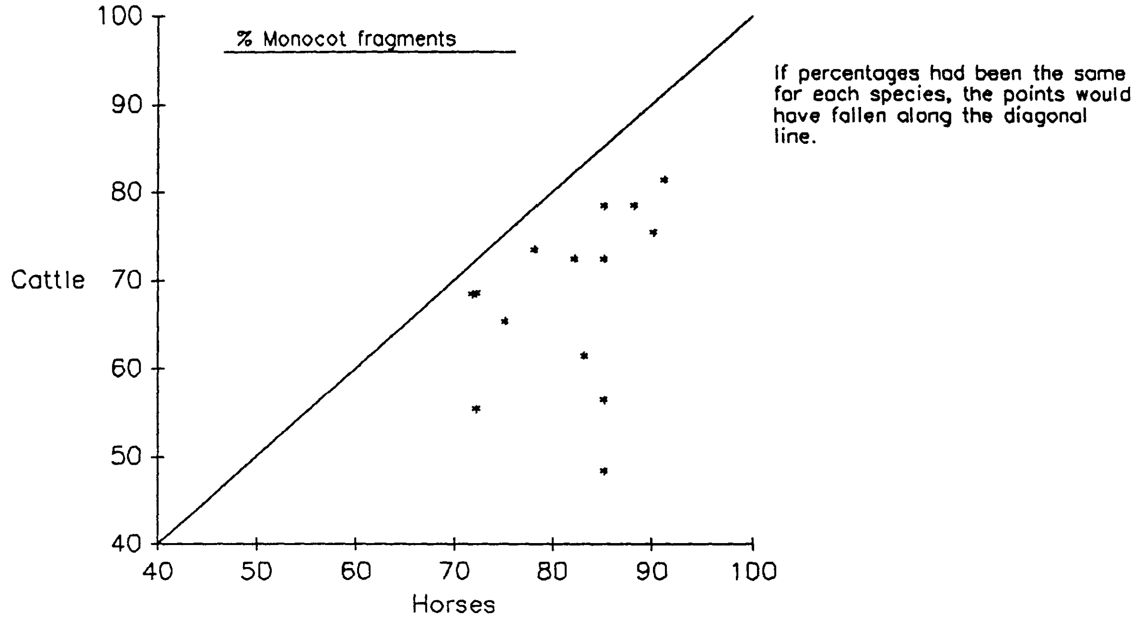

Figure 4.8: Percentages of monocot fragments in analysed faecal samples of horses and cattle, matched for place and date of collection.

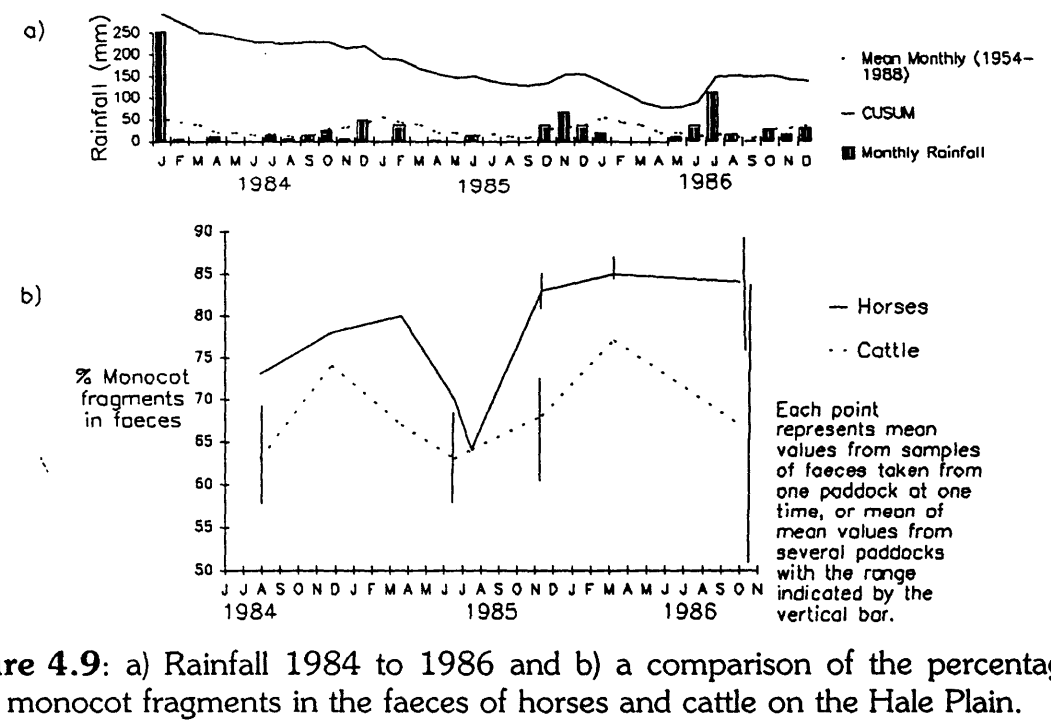

Figure 4.9: a) Rainfall 1984 to 1986 and b) a comparison of the percentage of monocot fragments in the faeces of horses and cattle on the Hale Plain.

These results suggest that both horses and cattle turn to dicot plants, which includes both forbs and "top feed" from shrubs and trees, when grass growth has ceased. However, there was no clear relationship between the proportion of dicot fragments in the faeces of either species and the apparent quality of their diet. Even when horses and cattle were eating large proportions of the most palatable genus, *Enneapogon* (the oat grasses), they both continued to eat substantial proportions of dicot material. In fact, there was a weak positive relationship between the percentage of dicot fragments in the faeces of horses and the percentage that *Enneapogon* fragments formed of the identified grass epidermal area.

Throughout all seasons on The Garden station grasses continued to form well over half the recognisable faecal material. Even in extreme drought conditions horses seem able to obtain an intake which is more than half grass. We (the Operation Raleigh team) collected stomach contents from horses which had died in drought conditions in Nineteen Mile valley (collected May 1986). The 6 samples averaged 66.2% monocot fragments. Because of this major dependence upon grasses, and because of the difficulties of recognising dicot species in faecal material, the rest of our analyses concern grasses only.

d) Quality of eaten grass species

Figure 4.10 compares the scored quality of samples of analysed faeces of horses and cattle collected at the same sites and times. It shows that horses usually (10 out of 13 matched samples) had a higher quality of composition of their faeces than cattle. This was largely produced by horses obtaining more *Enneapogon* (the only Excellent quality genus) than did cattle; this is shown in Figure 4.11. However, it is interesting to note that, in 10 out of 13 samples of horse and cattle faeces from the same sites and times, cattle had a higher percentage of epidermal area from genera that were ranked as Good quality than did horse. In 9 out of 13 matched samples, cattle exceeded horse faeces in the percentage of identified grass epidermal area from genera ranked as Moderate or Poor quality.

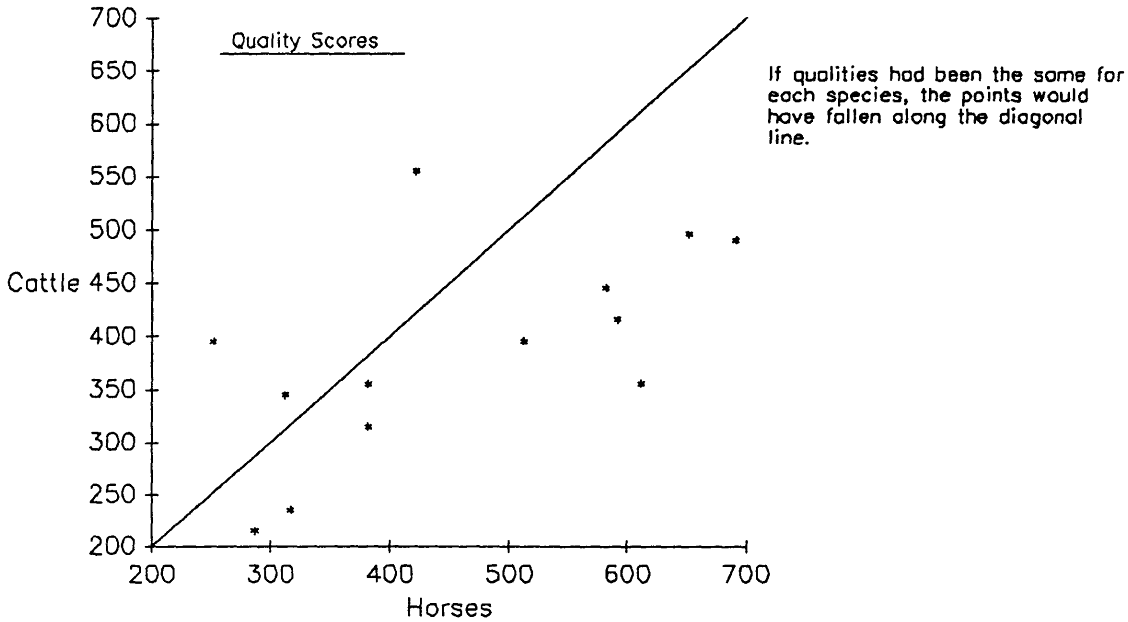

Figure 4.10: Quality scores (see text for derivation) for samples of faeces of horses and cattle, matched for place and date of collection.

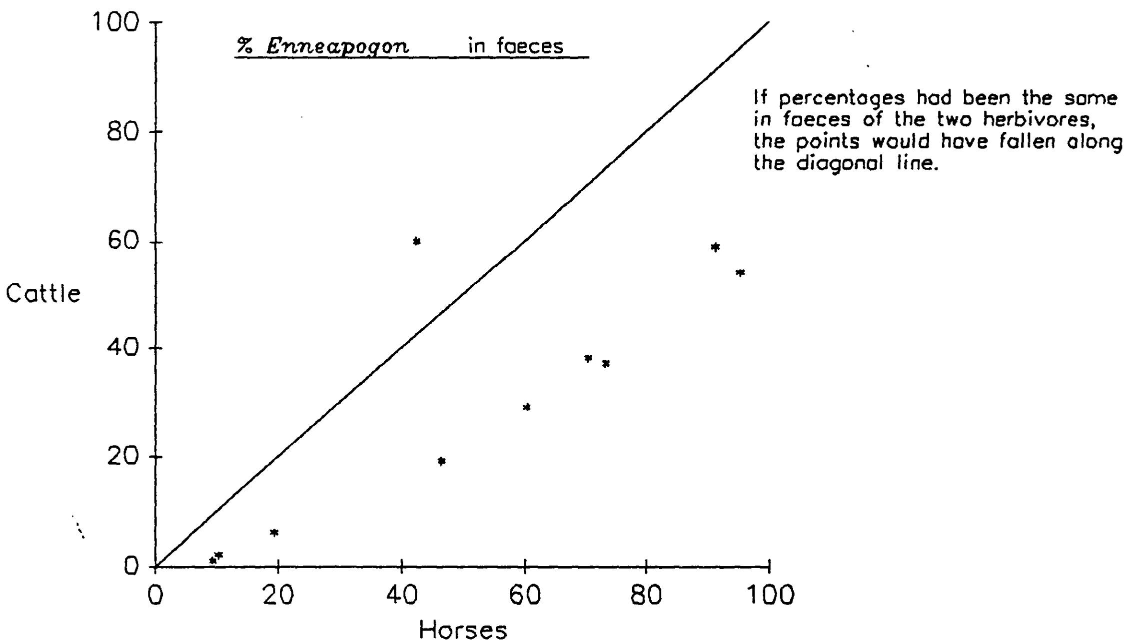

Figure 4.11: The percentage formed by *Enneapogon* of the area of identified epidermal fragments of grass in the faeces of horses and cattle, in matched samples collected at the same place and time.

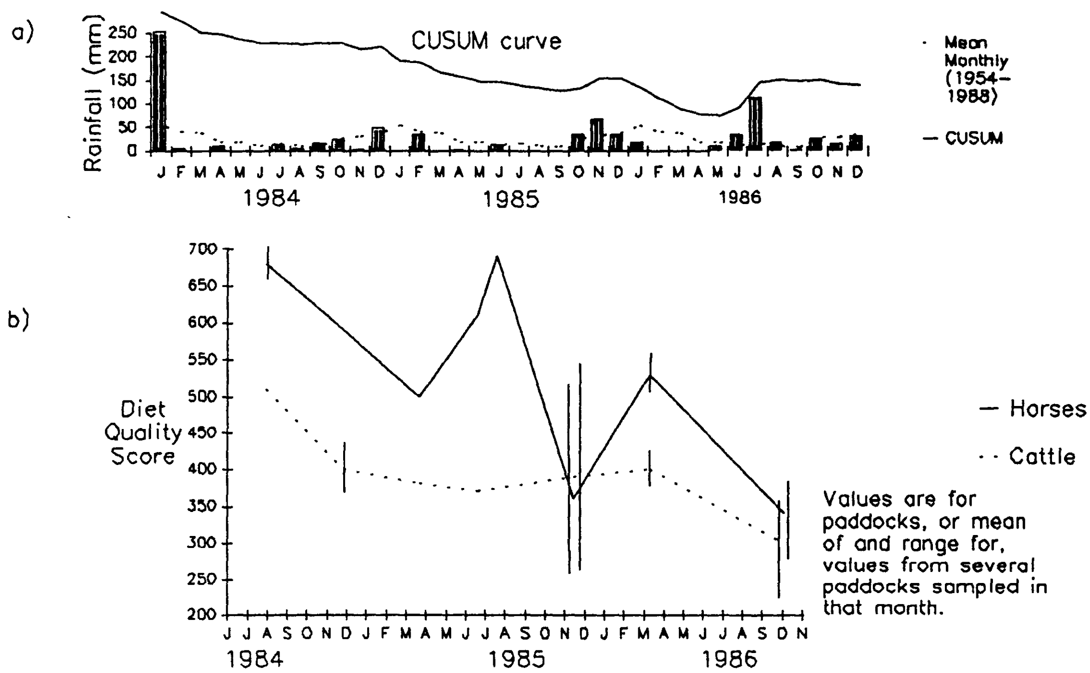

Figure 4.12: a) Rainfall from 1984 to 1986 and b) changes in the quality scores for the identified grass component of horse and cattle faeces on the Hale Plain.

These analyses reinforce the impression created in section 4.3.3.b) above that horses on The Garden station were able to feed more selectively on a smaller range of species, concentrating in particular on the Excellent-quality genus *Enneapogon* (the oat grasses).

There were variations through time in the quality of diet inferred by analyses of the faecal samples. These are illustrated in Figure 4.12. Quality tended to be highest for both species in winter 1984 and high for horses in winter-spring 1985 and autumn-winter 1986. However, the quality score used in these analyses is not really suitable for comparisons between seasons, since it does NOT make allowance for within-species (or -genus) variation in quality between seasons and with growth and maturity. Its use should be limited to within-season comparisons between horses and cattle. Used thus (values given in Table 4.5), it can be seen that horses using the same watering points and paddocks as cattle, usually (10 out of 13 cases) had better quality faeces.

These within-season differences between paddocks (or bores) in the relative qualities of faeces of horses and cattle feeding there reveal interesting aspects of each animal species' feeding strategy. Consider the September 1986 samples. In the White Dam area horses achieved a low-quality diet, but still better than cattle. This was one of the few cases in which horses had higher proportions of all three of the better quality

Table 4.5: Quality scores for horses and cattle faeces from different paddocks on The Hale Plain, showing variation between paddocks, and within a paddock through time.

Site	Quality Scores Horse (N)	Quality Scores Cattle (N)	*Period	Date of defecation
White Dam	649 (20)	514 (11)	1	Jul 84
Gidyea Bore	677 (4)	508 (13)	1	Jul 84
Top Bore	-	-	1	-
Cox Bore	616 (3)	368 (10)	1	Jun 85
White Dam	521 (4)	413 (10)	2	Jan 86
Gidyea Bore	571 (5)	450 (10)	2	Jan 86
Top Bore	427 (2)	570 (3)	2	Nov 85
Cox Bore	324 (1)	253 (2)	2	Nov 85
White Dam	281 (4)	220 (5)	3	Sep 86
Gidyea Bore	314 (5)	355 (9)	3	Sep 86
Top Bore	373 (5)	336 (9)	3	Sep 86
Cox Bore	378 (5)	362 (9)	3	Sep 86

There are two paddocks on the Hale Plain. Horses using White Dam and Gidyea Bore are separated by a fence from those using Top and Cox Bores.
*3 periods based on the quality and quantity of pasture.
Period 1: abundant, dry annual pasture,
Period 2: most annual pasture had been removed from flats and terraces but was available in unit B,
Period 3: abundant green perennial grass and herbaceous dicot pasture; very little annual pasture.

categories of grass genera (Excellent, Good, and Moderate) in their faeces than cattle, although the relative proportions of these categories in faeces differed rather little between the animal species. The White Dam area contains a more balanced representation of landform strata dominated by *Enneapogon* species (Excellent quality), *Astrebla* (Moderate quality) and *Aristida* species (Poor quality) than do the other three areas sampled in that month. In Top and Cox Bore areas, neither horses nor cattle found much *Enneapogon*, but achieved moderately good quality faeces by taking high and similar proportions of Good quality genera of grasses. By contrast in the Gidyea Bore area horses took more *Enneapogon* than cattle, but a lower proportion of Good genera, and more Poor genera, producing an overall lower-quality diet. In January 1986, horses feeding in the White Dam and Gidyea Bore areas, which both contain high (36 and 39% respectively) proportions of landforms dominated by *Enneapogon* grasses, had been able to obtain much better diets than cattle by taking large proportions of those species. Cattle had achieved their moderately good diets by taking large proportions of Good genera. The same was true (although the differences between the stock species were exaggerated) in July 1984 in the same two areas, and in the Gidyea Bore area in January 1986. When pastures were particularly poor in June 1985, horse and cattle faeces were sampled in the area around Cox Bore. This area contains a high proportion (84%) of land unit D dominated by *Aristida* species, which are of Poor food quality. Horses seemed still able to obtain a high-quality diet dominated by *Enneapogon* species, whereas cattle faeces, although they contained 39% *Enneapogon*, were dominated (52%) by Poor-quality genera, especially *Aristida* (Berman & Jarman, 1987).

e) Dietary overlap

As mentioned earlier this diet section largely comes from the report we prepared for the CCNT in 1987 (Berman & Jarman, 1987). The contract for that study specified that determination of dietary overlap should be one of the objectives. This is a particularly difficult topic, and one that has interpretational difficulties. Firstly, overlap should not be confused with competition; it is possible for two species to be eating identical diets (i.e. fully overlapping diets) but with minimal competition between them because food was in superabundance. It is also possible for faecal samples from the two species to show great dietary overlap, yet for there to be no direct competition because the animals were feeding in different areas. Later in Chapter 10 I will use the results of this section to make some suggestions about possible competition, but I have confined myself here to writing simply about "overlap".

Moreover, since we have analysed only the grass component of the diet in detail, and since we believe that horses and cattle are mainly choosing where and what to eat in response to the state of the grasses, this overlap has been calculated on the basis of grasses only. Furthermore, since most of the important grasses could be identified to genus more confidently than to species, we have calculated overlap at the genus level.

Overlap, then, has been calculated from tables of the mean proportions that each grass genus formed of the identified epidermal fragment area in samples of faeces of horses and cattle taken from the same site at the same time. The total percentage overlap was calculated as the common percentage of each genus. For example, if, in a sample, the average horse faeces contained 35% *Enneapogon*, 60% *Aristida*, and 5% *Astrebla* epidermis, and the average cattle faeces contained 15% *Enneapogon*, 80% *Aristida*, and 5% *Astrebla* epidermis, the percent overlap would be the sum of 15% from *Enneapogon*, 60% from *Aristida* and 5% from *Astrebla*, equal to 80% total. (None were quite this simple.)

Overlap ranged from 42 to 86%, most values lying between overlaps of a half and three-quarters in the grass component of the faeces (Table 4.6).

Seasonal variation in overlap may have been confounded by incomplete coverage of all sampling sites in most seasons (because either horses or cattle might be absent from a sampled area), but it appears that overlap was high when grass was growing, or at least still green, following rain. Not surprisingly, the more that horses and cattle depended upon one genus of grass, the more overlap there was between their diets if they were using the same genus, and the less there was if they were using different genera.

Table 4.6: The percentage overlap, of the identified grass component of faeces, at the genus level, between horses and cattle, by site and time. Periods were based on pasture quality and quantity (Table 4.4).

Period	Date	White Dam	Gidyea Bore	Top Bore	Cox Bore	Mean
1	84/7	70	60	-	-	65
1	84/11	-	54	-	-	54
1	85/6	-	-	-	50	50
2	85/11	-	-	66	86	76
2	86/1	54	67	-	-	61
3	86/9	71	57	77	42	62

This meant that after rains, when both tended to be eating the new growth of annual grasses, especially *Enneapogon* species, overlap tended to be high. As cattle diversified their diet, taking perennial grasses from genera ranked as of Good quality, but horses continued to use *Enneapogon*, overlap declined. Once horses and cattle both fell back on Moderate and Poor quality grasses, especially *Astrebla*, *Aristida* and *Sporobolus*, overlap either rose again, because both had chosen the same genus, or remained low.

We have here considered simultaneous overlap only, since that was most pertinent to the aims of the study. It should be remembered (and this is discussed in Chapter 10) that one herbivore's use of a grass species now may overlap with another herbivore's use of that species later, causing competition.

f) Comparison of White Dam and Gidyea Bore areas

The quality of pasture was estimated for land units B,C,D,F and G based on the relative proportions of grass genera determined by wheel-point transect (between July and November 1984) at representative sites (Table 4.2). The proportion of area of each land unit within 3 km of White Dam and also for the area within 3 km of Gidyea Bore was used to determine a mean quality value for food available for horses and cattle drinking at each of these watering points. A comparison could then be made between the available quality and that found in faeces. At Gidyea Bore the quality of the faeces for both horses and cattle was highest in 1985 because they were obtaining oat grasses (*Enneapogon* spp.) in the hills of unit B (Figure 4.13 & Figure 4.14). In the area around White Dam, however, the quality of the faeces was highest in 1984 and declined during the three years as annual grasses were removed from unit C and G. The quality of grass genera selected by horses and cattle was lowest in 1986. This was because grass genera rated as Poor quality food were green and probably of a sufficiently high protein content and digestibility to allow stock to remain on the flat land close to drinking water instead of searching for annual grasses in the hills. Furthermore, there was probably very little annual grass left even in the hills since there had been no effective summer rainfall since January 1984.

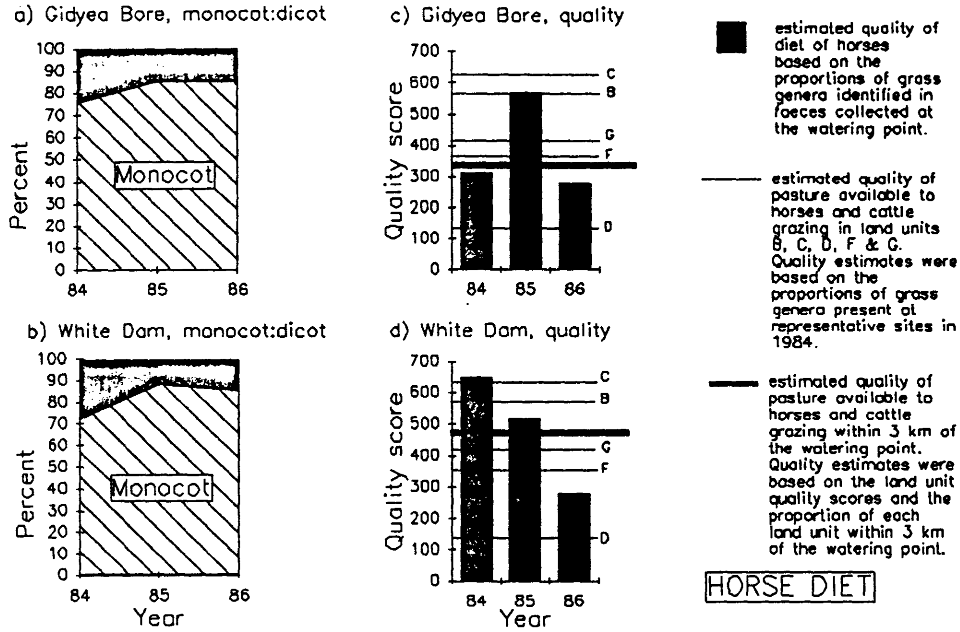

Figure 4.13: Shows (for horses defecating at Gidyea Bore or White Dam, 1984, 1985 & 1986) a comparison of monocot:dicot ratio a) & b) in faeces and a comparison of available food quality and selected diet (i.e. faeces) c) & d).

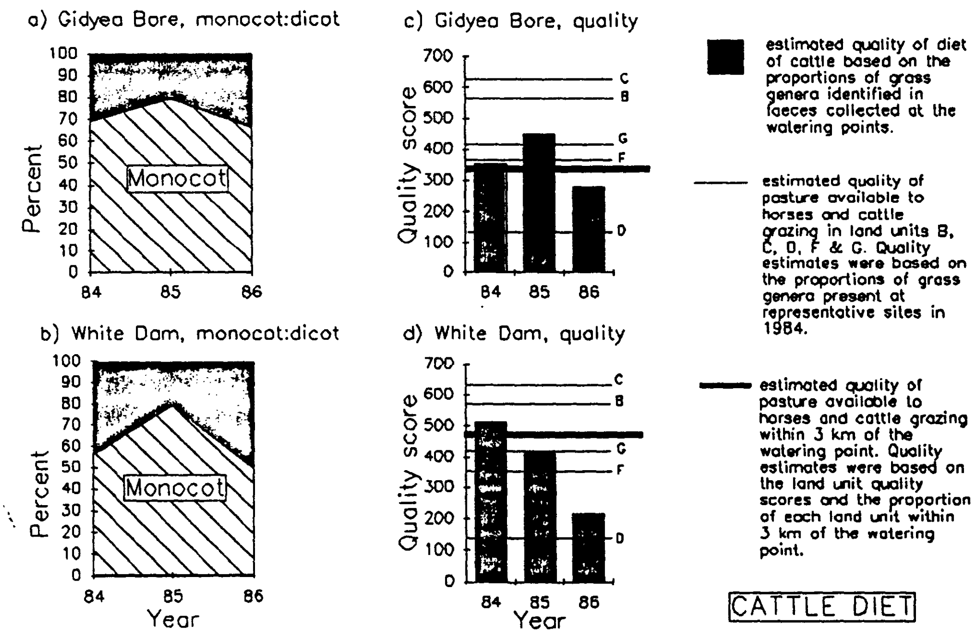

Figure 4.14: Shows (for cattle defecating at Gidyea Bore or White Dam, 1984, 1985 & 1986) a comparison of monocot:dicot ratio a) & b) in faeces and a comparison of available food quality and selected diet (i.e. faeces) c) & d).

Plate 6: Water-sources for cattle and horses. In March 1988 I saw over 100 horses waiting for a drink in the area shown by photo (a) at Porter's Soak. Horses dig in the sand to obtain water (b & c). Cattle use holes dug by horses or graded by men (b). Porter's Soak is permanent and the abundant hoof prints indicate its importance (a). Whistleduck Waterhole is semi-permanent (b). In (c) "Wobbly" is digging for water near Whistleduck Waterhole. Often during dry times foals were found dead or nearly dead near waterholes or soaks (d). Photo (e) shows lactating mares in poor condition at Gidyea bore and photo (f) shows a bachelor at Cox Bore with bite scares received during fights with other stallions. In October 1986 harem groups were seen resting in the shade near Top Bore (g). Photo (h) shows a flood replenishing waterholes in Trephina Creek.

4.3.4 Water

a) Types of watering places

Watering points can be classified according to their permanence. Bores and some natural, spring-fed water-holes always provide water even during the most severe drought and are called permanent watering points. Semi-permanent watering points are those that, when filled, provide water for periods longer than one year. These water-holes rarely dry up because there is usually at least one decent storm per year. However, during drought semi-permanent water-holes and dams do dry up. Ephemeral watering points are puddles or small water-holes that dry up at least once every year; the majority hold water for only a week or two after rain.

Two months after rain (27 May 1988) there were 26 watering points in a 7.2 km section of Trephina Creek (Figure 4.2). If this frequency is consistent for the other creeks in the Porter's Well area there are over 300 watering points in the area (900 km^2) for at least 2 months after rain. Only 4 of the 26 waterholes counted in the 7.2 km section of creek had a significant amount of sign of horses (Table 4.7). These 4 waterholes held water longer after rain than the others. A similar pattern occurs over the whole study area where there were 35 watering points that rarely dry up (once every 5 to 10 years) and only 4 that have never been known to dry up. At these 4 permanent watering points 30, 30, 60 and 300 horses were seen during the March 1988 helicopter survey. Fewer than 10 horses were seen at 11 watering points and none at the remaining 24 waterholes.

Large home-range sizes of between 52 and 88 km^2 were determined by radio tracking (Dobbie & Berman, 1990) in the Porter's Well area. Each home-range area contained many waterholes of varying permanency (Dobbie and Berman, 1990). When surface water was abundant after rain, horses tended to drink near to where they were feeding. Widespread ephemeral waters negated the need for horses to walk long distances to water. Horse sign was generally absent at long-lasting waterholes for up to 3 weeks after substantial rain. As ephemeral waters were depleted, horses became increasingly dependent upon the long-lasting watering points.

Table 4.7: Description of watering points in a 7.2-km section of Trephina Creek, 2 months after rain and water flow. Donkey (D), horse (H) and cattle (C) use were scored following the system explained in section 4.2.5.

no.	Surface Area (m^2)	Depth (cm)	Stock Use (0 to 5)	Description
1	<1	5	1D	Soak dug by donkeys or horses - be dry in a day or two.
2	1x(20 soaks)	5	1D	20 soak holes dug by horses - clear water - dry in a week or two.
3&4	0	0	1D	Soaks dug in sand but no water.
5	0	0	1D	Soaks dug in sand, damp but no free water.
6	5	10	2C	Puddle under River Red Gum, tadpoles, used by cattle.
7	<1	3	1D	4 soaks dug in sand, only 1 with water.
8	4	20	0	Deep hole on downstream side of tree in the middle of the creek. Will be dry soon.
9	15	50	2H	Used by horses. Tadpoles present.
10	<1	4	1D	Full of tadpoles. Will be dry in a day or two.
11	2	30	0	No tracks. Dry in a week or two.
12	3	30	2H	Contains algae. May dry up in a week or two.
13	150	60	1H	Both tadpoles and algae. Horse tracks but not many.
14	500	50	2HC	Plenty of horse and cattle tracks.
15	40	50	1HC	Tadpoles but no algae.
16	2	30	3HC	Soak dug in sand. Many tracks. No tadpoles or algae. This waterhole is called Gum Hole.
17	30	30	0	Some algae but no tadpoles.
18	0	0	1H	Two soaks dug in dry sand.
19	1	5	1H	One set of horse tracks. Dry in a day or two.
20	15	10	2HCD	Tadpoles.
21	30	30	1HC	Few tadpoles. Not many tracks.
22	1	10	1HC	One tadpole and algae.
23	200	50	3HC	Plenty of tadpoles. Heavily used by stock.
24	2000	100	4HC	Saw a mob of horses. Called Running Waters.
25	1	10	1H	Puddle with algae.
26	2000	50	3HC	Series of puddles and soaks called Porter's Soak.

Table 4.8: Number of adult horses visiting 3 water-holes during 36 hour periods starting at 1900 h continuing through 2 nights and 1 day and finishing at 0700 h. Day was from 0700-1900 h and night from 1900-0700 h.

Watering-points	Permanent water Porter's Soak		6 km from permanent water Whistleduck WH		12 km from permanent water Dead Horse WH	
	Day	Night	Day	Night	Day	Night
Adults/hour	0.3 (3)	3.1 (59)	1.0 (7)	0.6 (12)	1.2 (14)	0.8 (9)
Mares/hour	0.2 (2)	2.0 (38)	0.3 (4)	0.4 (5)	0.5 (6)	0.1 (1)

Table 4.8 shows the number of adult horses visiting watering points ranged from 0.3 to 3.1 per hour. During the total time Dobbie spent watching at these waterholes (108 hours) 3 out of 7 radio-marked horses were observed drinking. This crudely indicates that 43% of the horses in the area were seen to drink during the observation period and the total number of adult horses in the 300 km^2 area was 250.

Most watering points in the Kings Canyon study area are ephemeral or semi-permanent. In contrast the Garden Station is well watered. There are 16 bores, 5 dams and 5 permanent natural watering points for stock on the Garden Station. There are approximately 16 natural semi-permanent watering points that dry up only during the most extreme droughts (once in 10 to 20 years) and countless other ephemeral watering points that contain water for periods ranging from 2 days to 9 months without rain. On the Hale Plain there is only one natural watering point that has water for longer than 6 months. It is called Georgina Soak, is spring fed and has never been known to dry up.

b) Rate of drying

Fibreglass rods were placed in 6 of the larger water-holes to measure the rate at which water disappeared due to both drinking and evaporation. Figure 4.15 shows that the rate of decrease in depth of a water-hole is dependent on season. The time taken for a water-hole to dry up depends mainly on the initial depth but also on whether the water-hole is replenished from underground sources. Porter's Soak appears to be fed from underground sources and has never been known to dry up. In winter the rate of drying was 0.6 cm/day for 4 waterholes and 0.7 cm/day for another. Running Waters water-hole decreased at only 0.1 cm/day and Porter's Soak did not decline during the winter. Rates of decrease were more rapid during the summer ranging from 1.1 cm/day to 1.4 cm/day for all except Porter's Soak. Again Porter's Soak dropped least of all the waters measured (0.2 cm/day).

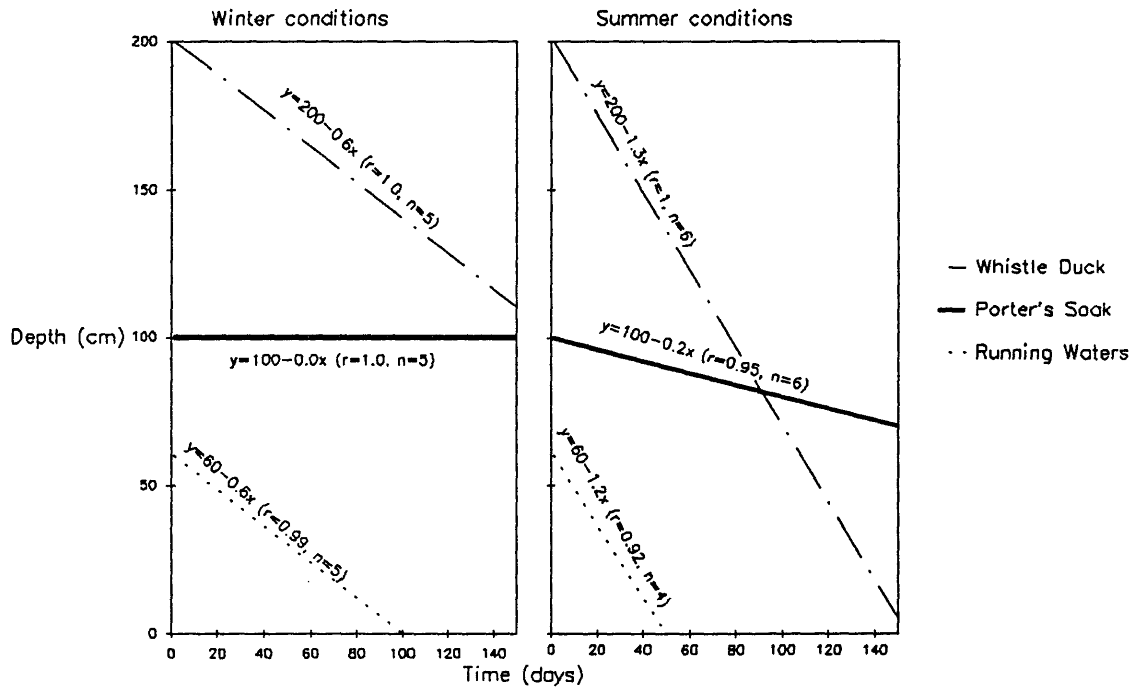

Figure 4.15: Rate of decrease in depth of watering-points in the Porter's Well area. Porter's Soak is permanent, Whistle Duck Water-hole is semi-permanent and the water-hole near Running Waters is ephemeral.

c) Importance of permanent water

Interestingly, although there were many alternative watering points when I surveyed the 7.2-km section of Trephina Creek (Figure 4.2), the greatest sign of horses was recorded near Gum Hole, Porter's Soak and Running Waters. These three were found to be the last to contain water during drought. Of these three only Gum Hole dried up during the study. In March 1988 only a small puddle remained at Running Waters and the majority of horses were drinking at Porter's Soak where over 300 horses were observed waiting for a drink or drinking there at the one time. Porter's Soak, having never dried up is obviously a very important drought-time watering place. I was about to begin radio-telemetry work in the area and was confident of being able to immobilise one of the 300 horses at Porter's Soak, but, before radio-telemetry equipment arrived from USA, rain fell, filling all waterholes on The Garden station. For almost three months after the rain no sign of horses was recorded at Porter's Soak. Where did those three hundred horses go? Restricted to watering in large numbers at Porter's Soak during drought, horses appeared to avoid the area when water was available elsewhere, perhaps because forage had become completely depleted in the area of Porter's Soak.

d) Frequency of drinking

Initially I attempted to follow horses with radio-collars and record time-budget data starting when the horses came in to drink and finishing when they next came to drink (Chapter 3). However, fatigue got the better of me and "between watering watches" were reduced to "24 hour watches". These "24 hour watches" confirmed that horses rarely came to water twice within 24 hours. Will Dobbie, who continued, under my supervision, the radio-tracking work initiated by me in the Porter's Well area, followed a horse group for 48 hours without seeing them drink. Unfortunately Dobbie became thirsty before the horses and had to return to his camp. These data show that central Australian horses can spend long periods (24 to 48 hours) without a drink and commonly do so.

e) Amount horses drink

In August 1985, I left my friend Dave Wurst at Top Bore to obtain a measure of the amount of water consumed by horses and cattle while I tried on horse-back (Athol's) to locate the radio-collared horse called "Brumby One". Wurst measured the drop in the level of water in a water trough after groups of horses and cattle had finished drinking. From this we calculated roughly the average amount of water consumed per individual. I rode 5 km into the very rugged hills to the north of Top Bore before I received a signal from "Brumby One". The direction to "Brumby One" indicated by my equipment was straight back towards Top Bore. Sure enough when I returned (2-hour ride) to Top Bore, Wurst reported having seen "Brumby One" and had recorded the amount of water his group consumed. Result's of Wurst's observations are in Table 4.9. Often both horses and cattle drank at the same time. However, Table 4.9 indicates horses on average were drinking a greater amount of water than cattle on any one occasion.

In chapter 3 I estimated horses drink on average once every 32 hours. Using this information and a value of 35 Litres per horse per drink (Table 4.9), in 24 hours the intake is 26 Litres per horse. From Table 4.8 the number of adult horses visiting Porter's Soak was 62 in 36 hours. At this rate 1075 Litres can be removed from Porter's Soak in 24 hours by horses. In March 1988 there were 300 horses seen at Porter's Soak. At that time horses were probably removing 7,800 Litres every 24 hours.

f) Social groups and water

Watering points can be thought of as "social centres" analogous to the pub, club or bar-b-q of humans. Soon after rainfall when pasture was plentiful and green, horses were seen in large herds, up to 100 individuals, feeding within 1 km of White Dam and Top Bore. Herds were not seen near Cox Bore, Gidyea Bore or Georgina Soak. Large harem groups were also generally only seen near White Dam or Top Bore, 2 of the 5 permanent watering points on the Hale Plain. Small harem (1 stallion, 1 mare and 1 juvenile) groups and bachelor groups tended to be the only groups seen at Cox Bore, and Georgina Soak. When water was available at White Dam, the alternative in that paddock, Gidyea Bore, tended to be a watering point for bachelor groups or small harems. When White Dam was dry all the horses in that particular paddock were forced to drink at Gidyea Bore. A detailed description of these data along with data from Dobbie and Berman's report is included in Chapter 6.

The watering points favoured by large harems (White Dam and Top Bore) were closely surrounded by a greater area of unit C than alternative watering points (Gidyea Bore and Cox Bore respectively). Perhaps even more striking was the difference in the amount of area of unit D within 3 km. Horses appeared to have a preference for the

Table 4.9: Estimation of the amount of water consumed by groups of horses and cattle visiting Top Bore.

Group No.	Mean (range) amount of water consumed by individuals (L)	Group composition: Horses	Group composition: Cattle	Time
1	22	4 (adults) 2 (yearlings)	4 (cows)	1140
2	28	-	1 (bull) 2 (steers) 2 (cows)	1330
3	35	6 (adults) 2 (sub-adults)	-	1430
4	39	3 (adults)	-	1505
5	32	4 (adults), 1 (9-month old) "Brumby One's" group	-	1530
6	20	4 (adults) 1 (foal)	4 (steers) 1 (bull)	1540
7	14	-	2 (cows) 3 (calves)	1710
8	7		1 (steer) 2 (cows) 2 (calves)^	1730
Cattle	16 (7-28)	-	All cattle	1130 to 1730
Horses	35 35 (32-39)	Adults All horses	-	

Temperatures 8 Aug 1985, Min. 0°C and Max. 19°C

^ At least one group of cattle were resting near the bore for much of the day; they may have had a drink before observations commenced.

pasture of unit C over that of unit D and the presence of herds and large harems in some areas but not others seems therefore a result of avoidance of alluvial areas (unit D) and/or selection of areas which grow annual pasture (unit C). Possible reasons for avoidance by horses of alluvial areas and the associated watering points are:

. the presence of poisonous plants (*Indigofera linnaei* and *Swainsona* spp.) which grew only on alluvial areas and no other during the study.
. alluvial areas have very few stones or rocks which may be important for maintenance of hoof condition. Areas of unit C were mainly pebbly terraces.
. alluvial areas grew mainly perennial grasses while the terraces of unit C grew the more preferred annual grasses.

4.3.5 Other resources

a) Shade

In all but land units F and G there are abundant trees that provide shade (Table 4.3). Of the 697 horses for which behaviour was recorded during transects on the Hale Plain (1984, 1985, and 1986 data combined) only 54 (8%) were seen in the shade. The greatest use of shade was observed during summer 1985/1986. Lack of forage at that time and increased distances travelled by horses from water to feeding areas may have caused horses to seek shade to conserve water. I have observed horses grazing in full sunlight in the hottest part of the day, when the temperature was 41°C. My horse (Rocky), used for ridden transects, often slept standing in full sunlight when the temperatures were greater than 40°C. Shade may therefore only become important when horses must conserve water to allow greater time in feeding areas and less travelling between water and feed.

b) Mates

Eleven percent of adult females (n=240) identified on the Hale Plain were in groups that had no adult males identified in the same group. This indicates that adult females have little trouble finding mates. In contrast, 49% of adult males (n=240) recorded on the Hale Plain were in groups with no adult females. During the spring single adult males were often seen in the vicinity of a watering point or following a group that contained female adults, probably trying to pick up a female. Watering points appear good places for single males to find mates. Social organisation is discussed in detail in Chapter 6.

c) Habitat and the avoidance of predators

In central Australia humans are the only significant predators. Dingoes probably take only sick or abandoned foals. Horses are chased by humans on horseback, motor bikes and in helicopters and they often escape by heading for the tree covered-hills. Horses are also trapped when they come to drink. A valuable resource therefore for a horse is an alternative watering point where traps are difficult to build. Such watering points are usually in rugged, tree covered hills where all forms of mustering are difficult.

4.4 Discussion

Horses and cattle can influence vegetation by trampling, grazing or browsing. Apart from the obvious removal of pasture by grazing, changes in floristic composition may also occur as a result of the selective removal of palatable species or because some plants are less tolerant of grazing or trampling than others (Buckley, 1985). The long-term impact of horses and cattle on vegetation is difficult to detect amongst the tremendous short-term variations due to climate. My studies have shown that great changes in the species composition and abundance of pasture are caused by amount and timing of rainfall.

As horses and cattle graze they reduce the herb cover. Immediately after rain stock graze close to water (Chapter 5) and therefore herb cover and height is reduced in such areas first. Pastures dominated by certain grass species (especially *Enneapogon* spp.) are preferred and are used first, whereas other grasses such as *Aristida browniana* are left until last. Use of pastures, indicated by reduction in herb cover, is thus affected by three factors: species composition of the pasture, distance from water, and time since the last rain-induced growth event. As grass is removed close to water, the horses and cattle respond by either feeding less selectively when close to water (mainly cattle), taking some of the relatively less palatable grasses as well as the highly preferred ones, or by moving further from water (mainly horses) but continuing to graze selectively.

The cumulative effect is that pastures close to water, particularly those dominated by palatable grasses, come under the greatest grazing pressure (Figure 4.5). The separate effects of horses and cattle are difficult to distinguish, since they eat a similar mixture of species and in time cover much the same range of habitats. However, it is cattle that make the greatest and most prolonged use of pastures close to water (Chapter 5) and are therefore most responsible for any changes induced in those pastures by heavy grazing. The more selective influence of horses is exerted further from water than that of cattle (Chapter 5).

Horses on the Hale Plain, like those in North America and, it is assumed, for their recent ancestors, feed predominantly on grasses. Salter and Hudson (1979) found that grasses, sedges and rushes made up the bulk of the food for an Alberta feral horse population. Some browsing and utilisation of mosses occurred during winter. Horses on the Hale Plain increased their intake of non-grass material only after 18 months of dry weather. Cattle more readily increased their intake of non-grass material than horses (after 12 months of dry weather) and more slowly returned to a diet of predominately monocots after rainfall. Although there was an abundance of dicots available in winter 1986 the faeces of horses contained even more monocot material than in the previous year (Figure 4.9), whereas, cattle utilized the abundant dicots.

As grasses dry out the protein content decreases. Herbivores may (if they choose to) supplement their protein intake by eating forbs and shrubs. Cattle appeared to more readily choose this option than horses. However, horses too appear to have increased their intake of forbs and shrubs during the winter of 1985 when pasture was extremely sparse. Nevertheless, unlike cattle, at that time horses also increased their intake of *Enneapogon* grasses. Since there had been little rainfall and no increase in biomass of these grasses at that time horses must have been taking advantage of the cooler, winter conditions to walk further or stay longer in the hills without coming back to the flats to drink. Cattle remained on the flats (Chapter 5) eating forbs, shrubs and perennial grasses.

On the Hale Plain there were only three bores, White Dam and Georgina Soak (a permanent natural watering point). Occasionally, soon after rain, there were many ephemeral watering points and horses no longer had to walk far from water to feed. These periods when drinking water was abundant close to food occur only occasionally and horses on the Hale Plain were generally restricted to the monotonous pattern of walking 3 to 6 km from feeding areas to the bores, White Dam and Georgina Soak (Chapters 3 & 5).

Permanent, semi-permanent and ephemeral watering points each have different implications for the survival of horses. Permanent water is required during drought. Soon after rain horses no longer need to travel to permanent water from where they are feeding because they can drink at ephemeral water. Ephemeral water allows horses to utilise pastures at distances normally too far from permanent water. Semi-permanent waterholes dry up during drought but act as permanent watering points during a run of good seasons such as occurred from 1974 to 1984. During this period horse populations were presumably increasing in size and were able to colonise areas where semi-permanent water occurred. During such a run of good seasons many horses may reach maturity without knowing the location of a truly permanent watering point and when drought comes they die. This is what appears to have happened in the Nineteen Mile Valley (1985/86) where there are many semi-permanent, but few permanent, watering points (Chapter 8).

Central Australian horses can spend long periods (30 to 48 hours) without a drink (Chapter 3). Similar results were reported for horses studied by Feist (1971) and Pellegrini (1971) in North America. However, when water is easy to obtain horses drink small amounts several times in one day according to Waring (1983). When free water is not available or difficult to obtain horses often dig soaks in sandy river beds. In North America Welsh (1973) also noted horses pawing holes in sandy soil to create a pool of water for drinking. Zebras do so in Africa also (P.J. Jarman pers. comm.). Cattle use soaks dug by horses or donkeys but tend to cause soaks to cave in. Cattle do not dig soaks, perhaps because their cloven hoof is unsuitable for digging or because they are more tolerant of stagnant water than horses. The equid hoof is useful not only for digging soaks but also for removing snow from forage in cold climates (Waring, 1983).

Information contained in this chapter provides the basis for understanding changes in activity (Chapter 3), habitat-use (Chapter 5), social organisation (Chapter 6), and population parameters (Chapter 7). Identification of the influence of distance from water on grazing intensity provided a means by which to study the environmental impact of horses and cattle (Chapter 8). In Chapter 10 I discuss the potential for competition or facilitation between horses and cattle using knowledge of their diet, and water-use contained in this chapter.

4.5 Conclusions

In this chapter I have described changes in the quality and quantity of pasture during my study. The overriding influence that determined these changes was the timing and amount of rainfall combined with the grazing of horses and cattle. The use of pastures by horses and cattle was affected by species composition of the pasture, distance from drinking water, elevation and time since the last rain-induced growth event. The extremely high variability in effective precipitation results in very unpredictable quality, quantity and location of resources for cattle and horses.

Horses consistently selected a higher quality diet with a higher proportion of monocot material than cattle. Cattle appeared to more readily take perennial grasses and non-grass material than horses. Differences in digestive strategy and mobility which are inextricably linked may explain the differences in diet of horses and cattle during my study.

The presence of horse herds and large harems at some watering points but not others seems a result of avoidance by horses of the poisonous or perennial plants that grew on alluvial areas and/or selection of areas which grow annual pasture. Permanent water is required for survival during drought. Semi-permanent and ephemeral waters allow horses and cattle to utilise pastures at distances normally too far from permanent water.