

1996 Fowlers Gap Research Report

BEHAVIOURAL AND ECOLOGICAL INTERACTIONS OF MAMMALIAN HERBIVORES IN THE ARID-ZONE HILLS

Investigators: Cate Athey and David Croft, School of Biological Science, UNSW

Fieldwork concluded in 1996 for this study which began at Fowlers Gap in 1994. The aim has been to investigate the effects on the behaviour and ecology of a population of euros (*Macropus robustus*) occurring in an area of overlap with populations of other species of mammalian herbivores in the hills of the arid zone. Euros are also known as the hill kangaroo and previous studies have found them to associate strongly with the slopes of hills; this is especially so of females. Euros are also known to be relatively unsocial amongst the species of large kangaroos and especially in comparison with introduced grazing species of sheep and goats. As a consequence of these aspects of the behaviour of the euro, we wish to see how unmanaged/natural populations of euros behave in their habitat of the hills in response to the presence of the introduced species - sheep, goats and rabbits. At the same time we have examined the degree to which the euro population overlaps populations of the red kangaroo and the eastern and western grey kangaroo within the study site. Finally we have compared the use of the area between the sexes in the euro population to determine how males and females interact with each other and with individuals of the populations of other species.

The study site has been broadly divided by its topography into the flats and the hills. In general the flats are used to stock most of the sheep because of the easier fencing and mustering and perceived better pasture than the hills, but sheep are also kept in paddocks in the hills. The study site at Fowlers Gap covers an area of 3.5 x 3 km within the paddocks of South Ridge, North Holding, Strip and South Sandstone. Sheep are kept in all of these paddocks at different times and densities. Feral goats and rabbits also occur in the area, and are subject to occasional population management control.

During the three years of field work, the following hypotheses were tested:

- That the population density and distribution of euros will be affected by the presence of other species of mammalian herbivores, that the density will decline in response to an influx or overlap with another species and that the distribution will be altered as euros shift away from the introduced species of herbivores.
- That as a consequence of moving away from other individuals within an overlapping area individual euros are likely to be displaced from areas of greater vegetation cover to poorer cover and the results of this can be measured as a trade off between a decreased reproductive output and survival, and an increase in home range to compensate for poorer cover.
- That the affects of overlap between euros and individuals or populations of other kangaroo species will be less pronounced and probably not apparent compared to that with the introduced species.
- That individual euros will limit the time spent associating in close proximity as in general only small groups have been identified together in past studies. In particular, male and female euros will limit the time that they spend together to reproductive-

related associations to minimise the time spent overlapping in the same area and on the same resources

- That male euros benefit from a strategy of having a larger home range than female euros, and that they gain a nutritional benefit from grazing to a greater degree than the female euros on the flats rather than in the hills.
- That this tendency for euros to minimise contact and spatial overlap between themselves and other individuals, will also be demonstrated at the water trough within the study site. In response to increasing densities of other species in the area, euros will alter their temporal drinking patterns and may even consume less water to avoid overlap spatially.

The results of this study are currently being analysed at the UNSW in Sydney.

FEEDING ECOLOGY OF RED KANGAROOS: A COMPARISON OF JUVENILES AND ADULTS

Investigators: Amanda Bilton and Terence Dawson, School of Biological Science, UNSW

The relationship between feed intake and the level of available food for a herbivore (often determined as plant biomass) is called the functional response. The importance of the functional feeding response is that it provides the key inputs into models dealing with the dynamics of kangaroo populations

The functional response of juveniles (weaned, young at foot) and adult red kangaroos (*Macropus rufus*) were investigated for a rangeland pasture dominated by chenopod shrubs. The investigation involved an intensive grazing trial. The diets of the two age classes were also compared throughout the trial. Diets and food intake rates were further examined using an optimal foraging model based on linear programming.

Both adults and juveniles showed highly variable intake rates in response to decreasing vegetation biomass. The method of measurement of the vegetation was considered to be the major contributor to this variability. The maximum food intakes of adults and juveniles were 80 and 84 g/kg^{0.75}.day, approximately 30% greater than the maximum value previously recorded for adults feeding on similar pasture. Intakes of the two age classes were similar despite a predicted increase in metabolic demand by the small animals. The level of biomass below which the animals could no longer maintain intake was approximately 40 kg/ha, much lower than the value of 250 kg/ha obtained by short. Juveniles had a higher harvesting efficiency than adults, indicating an increased ability to maintain intake at low vegetation biomass.

Under relatively 'good' pasture conditions, at the beginning of the trial, the diets of the adults and juveniles were similar. The diets diverged as pasture conditions deteriorated; the adults selecting a higher proportion of higher quality plants (grasses and forbs).

The energy maximising diets predicted by the optimal foraging model were different from the observed diets under relatively good pasture conditions. Under relatively 'poor' environmental conditions the energy-maximised diets predicted by the model were not

significantly different from that observed. The model also accurately predicted that both age classes were in negative energy balance.

A comparison of the intake rates determined from the functional response curves with those obtained from the optimal foraging model was obscured by the variation in the data from the functional response trials. Intakes determined via the optimal foraging model, however, reflected the decrease in intake rate and subsequent state of negative energy balance expected as pasture biomass decreases. This signifies the optimal foraging models potential for determining the functional response in free-range conditions.

Further functional response studies are necessary to determine the accurate feeding responses of juvenile animals to declining levels of pasture biomass.

HORMONAL RELATIONS OF MOULT AND BREEDING IN WHITE-PLUMED HONEYEATERS

Investigators: Bill Buttemer, Lee Astheimer, and Karen Fildes, Dept. of Biological Sciences and Dept. of Biomedical Science, University of Wollongong

Our past surveys have revealed that White-plumed Honeyeaters (WPH) are reproductively labile, but have predictable moult schedules each year. In some years summer breeding occurs extensively at Fowler's Gap and results in moult/breeding overlap. This situation is extremely uncommon in birds living in highly seasonal environment and birds living in such environments are known to have hormonal mechanisms to prevent temporal overlap of moulting and breeding. We have just finished a series of experiments to gain insight into the influence of breeding hormones on moult. We compared the effects of testosterone on moulting rates of WPH males to those of moulting House Sparrows (HS). Males of both species were divided into two groups: experimental birds were implanted with silastic tubes filled with testosterone, whereas control males were implanted with empty silastic tubes. Testosterone suppressed moult altogether in HS but only reduced the moulting rate by about 40% in WPH. We are now examining the effect of the testosterone implants in thyroxine (T4) levels in these two species, as T4 is known to be involved with moult in many avian species.

Our other ongoing experiment is examination of the relation between testes size and testosterone production in WPH. Our data so far reveal that adult males do not show full gonadal regression, but instead have testes no smaller than about 50% of maximum at any time of the year. Females, by contrast, show complete ovarian regression. We have examined the functional state of male testes by injecting LH/RH intrajugularly in males followed by subsequent plasma sampling 5 and 15 minutes later to quantify LH secretion by the anterior pituitary and testosterone production by the testes, respectively. Our analyses thus far reveal no correlation between testes size and LH or testosterone secretion. We are now investigating the state of sperm production in testes as a function of gonad size.

INTEGRATING REMOTE SENSING TECHNIQUES FOR GEOLOGICAL AND SOIL MAPPING INVESTIGATIONS AT FOWLERS GAP

Investigator: Rob Hewson, School of Applied Geology, UNSW

This research is investigating the capabilities of thermal infrared, synthetic aperture radar and airborne geophysics remote sensing techniques to discriminate geological and soil units in an arid environment. Airborne high-resolution thermal infrared (TIMS) and radar imagery (AIRSAR) has been integrated with airborne radiometric and magnetic data to discriminate key minerals and structural/topographic controls on the geology. Subtle geomorphological and colluvial/alluvial features have also been identified in this research. Detailed fieldwork in 1994 and 1995 have previously mapped mineralogical and soil textural variations over the area surveyed by thermal and radar imagery. Fieldwork in 1996 investigated the anomalies identified from airborne radiometric and magnetic data.

A short field trip was conducted at Fowlers Gap in November 1995 to ground truth interpretations made from airborne radiometric and magnetic data obtained from the Australian Geological Survey Organisation. Thirteen survey lines were measured with a portable Gamma ray spectrometer over anomalous features and boundaries identified from radiometric data. Magnetic susceptibility measurements were also obtained from soil and surface scree deposits to assist the interpretation of aeromagnetic data. A final groundtruthing of TIMS thermal imagery was also carried out in November.

The TIMS data was corrected for atmospheric effects and reprocessed into thermal emissivity data. Laboratory measurements of thermal infrared reflectance (FTIR) spectra for a selection of Fowlers Gap soils and rocks were obtained from NASA's JPL and John Hopkins University. These FTIR measurements were resampled into the six bands measured by the TIMS thermal infrared scanner to assist in the interpretation of the processed emissivity image data. The limited FTIR laboratory sampling of Fowlers Gap soils suggested that grain size effects can be observed from thermal infrared scanners such as TIMS and the future ASTER satellite. Spectral unmixing of the TIMS data produced four endmembers or ground cover components in the area: quartz, shales/clays, dry vegetation on fine soils/sediments, and green vegetation on fine soils/sediments.

Airborne radiometric data has been proved to be strongly influenced by alluvial processes at Fowlers Gap, particularly on the floodplains of the Fowlers Gap Creek northeast of the Picnic Creek/Silver City Highway crossover (Conservation paddock). Shales and phyllites are particularly well defined by the potassium and thorium radiometric channels. The aeromagnetic data tends to show deeper structural features and boundaries however an alluvial fan pattern, similar to the radiometric anomaly, is observed on the floodplains of Fowlers Gap Creek. Ironstone rich piedmonts are also observed in the aeromagnetic data where maghermite may be developed.

Integration of the radiometric, radar and thermal datasets has been shown to provide a more complete geological and geomorphological interpretation than when the datasets are interpreted separately. The unmixed TIMS data identifies both the shale and clay rocks and soils while the radiometric data identifies the potassium-bearing shales/phyllites. The radiometric data also detects minerals at a greater depth than the TIMS imagery and

identified shales/phyllites underneath transported quartzite/sandstone scree. Soil and colluvial sediment textures interpreted from multi-wavelength AIRSAR images compares favourably with the coarse grained quartz/sandstone scree covered piedmonts identified from TIMS images.

EFFECT OF BODY SIZE ON FORAGING BEHAVIOUR OF EUROS

Investigators: Monika Klede¹, David Croft², Udo Ganslosser¹

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A five and a half months study was conducted at Fowlers Gap to investigate aspects of the feeding ecology of the euro (*Macropus robustus erubescens*) in relation to differences in body size. The aim of the study was to relate food quantity and composition to the euro's energy requirements and digestive physiology and to relate foraging behaviour, movement, vegetation composition at feeding sites and vigilance to the individual's size class.

Plant density and distribution were sampled by the wandering quarter method. Plant quality was characterised by the product of greenness and size of a plant, and by the water content, which was sampled on a monthly basis. The behaviour of euros while feeding was observed during dusk and dawn. In addition data on group size and bite size of euros when feeding on different food plants were collected.

The water content of the food plants was related to rainfall. The quality of food plants did not differ between the euro size classes. Mean group size was 1.8 which is smaller than the average group size in other studies and fewer large males with females were observed than in other studies. The scarcity of large males could be related to an extremely dry year before the study period (1994: 95 mm rainfall), because their number has been found to decline in dry conditions due to high mortality. A relationship between group size and plant distribution was found. The more defensible a vegetation site was, the smaller the group size. The feeding ecology of the euro was related to body size. Large males fed on plants containing more fibre than fed on by small males. Large males are better able to use poor quality forage due to their relatively larger gut size. The quantity of plants eaten was related to body size. However, quantity did not increase in proportion to body mass but rather was better related to metabolic rate through $M^{0.75}$.

Large euros occupied habitat with relatively low quality plants but selected the most digestible plants from amongst these. Small euros fed in areas with relatively high quality food. They were more selective of high quality plants than large euros. Vigilance was related to group size and body size. The larger the individual was then the higher its group size and level of vigilance. The proportion of time spent moving was inversely related to energetic costs. The frequency of walking decreased with increasing body size. This could reflect either a large stride length or a decrease in selecting amongst plants. Large males with females spent less time foraging than those alone. Males with females appear to trade-off foraging against mate acquisition and defence.

DISCRIMINATING VEGETATION COMPOSITION WITH HIGH SPECTRAL RESOLUTION IMAGERY

Investigator: Megan Lewis, Department of Environmental Science and Management, The University of Adelaide

This research is evaluating the use of airborne scanner imagery of high spatial and spectral resolution for discriminating and mapping vegetation composition in arid landscapes. Fowlers Gap provides the setting for the work, which is being conducted towards a PhD by Megan Lewis in the School of Geography, University of New South Wales, and supervised by Associate Professor Tony Milne. The study is comparing a range of satellite and airborne image types including Landsat Thematic Mapper, airborne video, Geoscan II airborne scanner and CASI (Compact Airborne Spectrographic Imager) all acquired over Fowlers Gap from 1993 to 1996.

Ecological information is being extracted from the imagery using conventional processing techniques such as classification, and newer approaches such as spectral mixture analysis, matched filtering and spectral matching, which aim to identify and quantify sub-pixel components of the landscape. The study places considerable emphasis on calibration of image components against quantitative field data.

1996 was the last season of field work and image acquisition for this project. CASI airborne imagery was acquired in April in a 25 x 2 kilometer swath over a range of Fowlers Gap land systems, and 90 ground sites sampled in March and May. The imagery is at 3 metre resolution and has 19 narrow wavebands in the visible and near infra-red portions of the spectrum, and shows considerable spatial and spectral information about soil, rock and vegetation types. Visible and near infra-red reflectance spectra of the dominant vegetation species, and of soils and rocks at the field sample sites were collected with a FieldSpec spectroradiometer to provide reference standards against which the imagery can be calibrated, and the spectral components identified.

Earlier sections of the work are in press or being prepared for publication. The land cover classification using "wet" and "dry" images from January and June 1993 successfully discriminated nine vegetation associations and related these to an objective vegetation classification. The vegetation classes mapped by the imagery also successfully predicted field cover classes for 50 independent verification samples. Spectral unmixing of the same imagery mapped sub-pixel abundances of photosynthetic and non-photosynthetic vegetation, soil, exposed rock and the quartz pebbles that are a characteristic feature of many Fowlers Gap land systems. Linear regressions were established between image estimates of most of these components and field measurements of percentage cover. The distribution of photosynthetic vegetation component changed dramatically between the wet summer of 1993 and the subsequent dry winter. Despite the 18 spectral bands of the Geoscan imagery acquired in January 1993 only one vegetation component could be spectrally identified, since most perennial and ephemeral species were actively growing at the time and had similar spectral characteristics. However, because of the narrow short-wave infra-red bands of this imagery which show absorptions characteristic of specific minerals, several soil and rock types could be distinguished.

Trials with the airborne video system showed its value as a reconnaissance mapping and land assessment tool, and established correlations between image and field estimates of tree and ground covering vegetation at specific sample sites 2,3,4. However, because of the calibration required to relate field and image estimates of cover, the airborne video is most useful as an adjunct rather than replacement for ground data collection.

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AN UNDERSTANDING OF THE MECHANICS CONTROLLING THE FORM OF CHENOPOD PATTERNED GROUND, WESTERN NSW:- COMPLETION OF SOIL SAMPLING AND VEGETATION SURVEYS

Investigator: Ben Macdonald, School of Geography, UNSW

The aim of this project is to use the soils physical and chemical properties to understand the processes controlling the form of different areas of patterned ground at Fowlers Gap Station. During the first two months of session two (1996), fieldwork was carried out at Fowlers Gap Station. Below is an outline the work completed to this date.

Previsional study sites were selected after a detail search of the 1986 1:10,000 Fowlers Gap Station air-photo set for areas of patterned ground, which would fit the project criteria. These previsional study sites were reduced to a single site, by field checking during 1995-6, within Hotel Paddock. The study site was located within this paddock because it occurred on a relict alluvial fan, encompassed four different forms of patterned ground, vehicular access was possible due to a power line road, and at the time of the completion of the vegetation surveys was under the minimal influence of the pio-sphere effect.

A series of 4 trenches were dug into the four different forms of patterned ground within the Hotel Paddock site. The depth of each of the trenches was to be 2m, but the front-end loader did not have the sufficient power to complete the task. The trenches as a result were of varying depths between and within each individual trench. The lengths of each of the trenches were also of vary distances, because it was determined by the spacings of the vegetated and bare areas of the patterned ground which occurred at the trench sites. The alignment of the trenches upon the surface of the relict fan is such that the trenches are on roughly placed on transect in a down-slope direction.

The final soil sampling strategy was decided upon after the inspection of each of the trench sites, which was that, a minimum of 14 soil sampling sites would be located on one of the side walls of the trenches, the location of these 14 sampling sites would be within the centre of the bare and vegetated zones and at the boundaries of these zones, samples would be taken at constant 10 cm intervals to depth and the first 10 cm interval would be sub-sampled, to include variations due to cryptogamic crusts, at 1, 2.5, 5, and 10 cm from the soil surface, the samples taken would not be biased and would include coarse fraction as well as fine fraction, and where possible auguring through the floor of the trench at each of the 14 soil sampling sites was carried out to compensate for the short comings of the tractor and allowed for soil samples to be taken from deeper in the profile

The soil samples were placed in snap-locked bags, the air evacuated and transported back to Sydney for laboratory analysis. At every sample site detailed profile description using McDonald et al., (1990). A vegetation survey using a modified line-intercept method was conducted at each of the trench areas. The samples and data collected from this fieldwork will be analysed and hopefully completed during 1997. I would like to thank all the station staff and researchers for making my stay most enjoyable and to all those that came out into the field and give me their assistance.

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THE USE OF IMAGE CLASSIFICATION FOR STONE DISTRIBUTION AND SHAPE

Investigators: Ben Macdonald and Allan Evans, School of Geography, UNSW.

The measurement of the coarse fraction of soils and in streambed deposits is not a precise science. There is still disagreement in the literature about the most practical ways to gain statistically acceptable measurements (Dunkerly, 1994). Gale and Hoare (1992) methods of bulk sampling has been refuted by Dunkerly (1994) as being insensitive to some aspects relating to stone parameterisation and that their method is physically impossible to carry out.

Dunkerly (1995) however advocates the use of mean diameters weighting by stone surface area and perimeter length as a better parameterisation of stone geometry. Dunkerly (1995) states that "these weighting factors have the advantage that they relate closely to stone characteristics relevant to slope hydrology and erosion processes". Another advantage of Dunkerly's (1995) method is that sampling time is very quick compared to other methods.

The aim of this current research is to improve Dunkerly's (1995) method by using image classification to improve the speed of which the data can be analysed. At the present time the research has been centred on the refinement of the computer software for the image analysis of the stone shape and size. Once this is completed trials will begin in the School of Geography's out door loading area using stones and soil collected from Fowlers Gap.

These trials will be used to find the ideal system set-up; some aspects are outlined below;

the use of digital imagery vs standard photographic techniques

the resolution requirements for the software,

method of camera mounting, and

the problem of overlapping stones.

Once the bugs and problems have been removed from the system, field trials will begin at Fowlers Gap to test if the method is robust in the real world. It is believed this method will further the research into the geomorphic evolution of the physical landscape.

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SOIL CATION DISTRIBUTION IN CHENOPOD PATTERNED GROUND, ARID WESTERN NEW SOUTH WALES, AUSTRALIA

Investigators: Ben Macdonald¹, Mike Melville¹, and Ian White²

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The study of the origins and characteristics of patterned ground in arid Australia has generally been confined to the relationship between the hydrological regime and its control of plant growth. There is usually only a secondary consideration given to the soil's chemical and physical properties and subsequently they fail to emphasize the spatial variation of soil properties in patterned ground. Studies do exist which have established patterns of association between vegetation distribution and soil properties that range in scale from that of the broad geological province (Noy-Meir, 1974) to that of soil changes around individual shrubs (Charley, 1972).

Our study shows the characteristics and proposes the processes controlling of the cation distribution in chenopod patterned ground within an enclosure in Airstrip Paddock at a scale intermediate between that of Noy-Meir (1974) and Charley (1972). It is believed that there is an important interrelationship between soil hydraulic properties, soil cations, soil swelling properties and plant spatial variation across the patterned ground landscape.

Part of this paper was presented at "Banded vegetation patterning in arid and semi arid environment" symposium and the whole paper is currently under review for a special edition of Catena.

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A COMPARISON BETWEEN THREE DIFFERENT SITES OF PATTERNED GROUND GILGAI COMPLEXES: AN INSIGHT INTO THEIR FORMATION

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Patterned ground gilgai complexes are one of the most common land-units on pediments in the arid zone of western New South Wales. Patterned ground is a land-unit where the spatial variation of vegetated and bare areas are rhythmically repeated. The microtopography of the complex, generated by the gilgai phenomena, causes the redistribution and concentration of sheet run-off into the vegetated areas. The system can support more vegetation than that is allowed under the environment conditions.

Within the patterned ground system there are also spatially repeated variations in the soils chemical and physical properties. The bare areas generally are self-sealing and semi-impervious to water and are "salt dumps". The gilgai complex has established a system where soil moisture and osmotic gradients all favour the flow of soil water carrying soluble salts from the vegetated areas and the bare area's subsoil concentrating it into the bare areas topsoil. The patterns of soluble salt distribution are a product of complex response as the soils become adjusted to the preferential inputs of run-off water into the vegetated soil due to the gilgai complex.

Most studies of patterned ground gilgai complexes are concerned with system operation in regards to hydrology, soil chemistry and vegetation at a small scale to macro-scale studies relating climate to the various forms of patterning. There are a few, if any, studies which have look at the differences between patterned ground gilgai sites located on different parts of a relict alluvial fan. The aim of this paper is to gauge if there are any differences between 3 different patterned ground sites on an alluvial fan within Hotel Paddock at Fowlers Gap Station. It forms the basis of a preliminary study of the change in form of patterned ground gilgai complexes in the local complex

Part of this paper was presented as a poster paper at the Regolith '96 : The state of the Regolith, Second Australian Conference on Landscape Evolution and Mineral Exploration and a full version is being submitted for the Journal of Arid Environments.

FOWLERS GAP STATION WALKS

Investigators: Ben Macdonald, Marc Robson, Richard Jessop and Allan Evans, School of Geography, UNSW.

The Fowlers Gap Management Committee decided during its last sitting (September 1996) that the Station should have a number of "ecological and educational" walks for its many visitors. The designs of these walks are suited for all that might visit the station, from the scouts to the more senior members of our community. The walks have been classified into different categories to inform the user of what he/she will face on the track. The categories are listed below:

Category 1. The easy walk. Anybody who can walk will find this walk very non-challenging.

Category 2. The non-easy walk. The length of this walk might challenge older folk. The walk is generally on flatter ground.

Category 3. The difficult walk. The length and terrain of this walk will make this walk very challenging for the older folk and difficult for the unfit.

Category 4. The long difficult walk. This walk is similar to 3 but longer and harder.

Category 5. The over-night walk. This walk is similar to 4 but it involves over-night camping. It would be recommended that the walkers be confident of their abilities before attempting this walk.

In all approximately five to six walks have been planned and are ready for construction. It is proposed that the tracks should be completed by the end of Session 1, 1997, with the construction period over the Easter break.

The nature handbook which will accompany the walks is designed to enlighten the visitor to the many different aspects (eg vegetation, pastoral, geological etc.) of the station. The directions and map for the walks will be presented upon a separate A4 or A3 page.

It is proposed that a walk information board should be placed in the library at the station. The board will outline the different walks to be done at the station and a full map of the station will also be displayed. The nature handbook and walk notes for the different walks will be located near this display board.

THE QUANTITATIVE ASSESSMENT OF BLADDER SALT BUSH (*Atriplex vesicaria*) RANGELANDS USING REMOTELY SENSED IMAGERY AT FOWLERS GAP STATION

Investigators: Marc Robson and Qiming Zhou, School of Geography, UNSW.

Shrub steppes occupy approximately 308,000 km² of the Australian mainland. These communities are generally composed of clumped woody perennial shrubs separated by areas of bare ground, however, following rain these bare areas become covered by low annuals, grasses and forbs. The shrublands are highly regarded by the pastoral industry and have been

utilised for the grazing of sheep and cattle since the 1850's. Coincident with the initiation of grazing practices was large-scale land degradation due primarily to overgrazing. Over time the community structure of the shrublands was changed through the removal of the perennial shrubs by stock, with subsequent erosion and replacement by other species. This mismanagement resulted in a decline in the carrying capacity of the rangelands as large tracts of once productive shrublands were replaced by unpalatable vegetation and scalded surfaces.

In order to manage the rangelands in a sustainable way it is important to maintain the cover of perennial shrubs as it is these plants which are primarily responsible for protecting the soil from erosion. Thus, perennial shrubs should be regarded primarily as maintainers of landscape stability and secondarily as a forage resource by the land manager. The most crucial time for the manager is in dry periods when all the preferred forage (forbs and grasses) has been removed leaving only the shrubs to graze. Decisions must be made, based on the state of the shrubs and soil condition, as to when stock should be relocated. This three year project is being undertaken with the aim of providing the land manager with quantitative information concerning rangeland condition with particular emphasis on the perennial shrub component.

Bladder Saltbush (*Atriplex vesicaria*) was selected for this study because of its wide spread distribution and sensitivity to grazing. This species is generally preferred to other perennial shrubs as a source of forage when the more palatable grasses and forbs have been eaten and as such, should be carefully monitored to ensure its persistence during those times in which it is being grazed. Remotely sensed satellite data is particularly suited to this task as it can provide cost effective and continuous information on rangeland condition at the scales required by the pastoral industry. Problems remain however, to relate the spectral reflectance measurements recorded by satellites to quantitative surface variables such as cover and biomass.

This project will attempt to produce a methodology which will allow for the extraction of quantitative surface variables from imagery recorded by the Landsat TM sensor. This information will be used to construct a rangeland GIS which will aid the land manager in maintaining the stability and therefore, the productivity of the land.

MICROSATELLITE ANALYSES OF *Rhytidoponera* sp.12

Investigators: W. T. Tay and R. H. Crozier, School of Genetics and Human Variation, La Trobe University, Bundoora 3083.

Developing further the population structure findings discussed in the previous report (Tay et al., 1997), intra- and inter- colony relatedness in the queenless ponerine ant *Rhytidoponera* sp. 12 is being investigated using five highly polymorphic microsatellite markers developed from a *R. sp 12* genomic DNA library. Ant samples collected during 1996 will be used to study genetic distances between individual colonies over a three-year sampling period. The gamergate (egg-laying workers) turn-over rate in *R. sp. 12* will also be investigated. One colony was completely excavated from Conservation Paddock. The depth of the colony was estimated at two metres. No males were found in this colony, while approximately 460 workers were collected. These workers were kept alive for approximately 6 months under laboratory conditions. Workers were colour coded and egg-laying individuals recorded.

Gamergates were identified by dissection using ovarian activity and/or spermathecal content (Pamilo et al., 1985; Peeters, 1987). Unmated workers of *R. sp. 12* from this colony were found to lay trophic eggs. This supported the study of Pamilo et al. (1985) that laying of trophic eggs by unmated workers were possible. This finding did not support the observations of Peeters (1987), although different laboratory conditions under which these nests were kept may have contributed to the differences noted. Sperm DNA isolated from gamergates is being used to investigate the mating behavior in *R. sp. 12* through typing of the mates of the gamergates.

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SPATIO-TEMPORAL INTERACTION OF MAMMALIAN HERBIVORES IN THE ARID ZONE

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This project investigates the interactions between four species of kangaroos (Red Kangaroos, Western and Eastern Grey Kangaroos and Euros), sheep, rabbits and goats in plains habitat and the foot-slopes of the Barrier Range at Fowlers Gap. 'Total grazing pressure' and associated appropriate stocking/control rates to conserve vegetation, soil and water resources are examined, and the possibility of mixed species grazing as a possible diversification of an economic base for the land-holders in the Western Division is explored. The study aims to set up a GIS as an aid for better management of the herbivore assemblage in the arid zone with respect to sustainable long term use and to allow for faster recovery from the impact of past overgrazing.

For this the interactions between the species have been assessed since March 1994 and this will continue through to March 1997 at both the population and the individual level in four paddocks (410-720 ha), of which two are stocked with sheep. The paddocks under study incorporate four different land systems and twenty different land classes with their associated vegetation communities. The populations of all species are monitored in space and time by monthly population surveys, analysing, for example, habitat use, to look at habitat segregation or overlap and at possible interference competition, age/sex class composition etc.

The surveys have so far shown highly fluctuating densities of Red Kangaroos, which along with sheep are the most abundant species. Densities have ranged from as low as five to as high as 150 individuals Km⁻² in response to unpredictable and patchy rainfall and associated poor or

rich vegetation conditions, although at 'average' times there appears to be a relatively stable resident population in the study area. Red Kangaroo numbers decreased in both paddocks stocked with sheep with the onset of lamb dropping, suggesting avoidance by Red Kangaroos when ewes are characteristically more dispersed within the paddock. Red Kangaroos suffered significantly during the drought conditions in 1995, however, allowed for higher survival, and recruitment increased significantly. Sheep losses during all times were low with the few cases of death due to occasional fly-strike. Lambing rates were good to excellent.

Western Grey Kangaroos, apart from sheep the species with the most similar habitat requirements to Red Kangaroos, have maintained small but stable populations over time. Although recruitment was lowered in drought conditions, they were still more reproductively successful than Red Kangaroos and continued to be so in 1996. This high recruitment probably offset the mortality due to the conspicuous cases of choroid blindness in the population. Eastern Grey Kangaroos are present in very low numbers only and have shown a marginal impact on the plains and foot-slope habitat, preferring the dense lateral tree and shrub cover close to large creek beds. Euro numbers vary greatly according to environmental conditions and only males make use of the lower lying areas, females mostly remain in the hills and never venture past the foot-slopes of the hills even in extremely poor conditions.

Goats are highly transient and can appear in large mobs, their appearance often coinciding with deteriorating conditions or a build-up in numbers. The colonisation of the area by rabbits appears quite stable. About 120 rabbit warrens have been mapped in the study area with most warrens situated on the foot-slopes, along drainage channels and large gullies. All warrens have been surveyed by counting active entrances on a three monthly basis. The rabbit population appears to fluctuate slightly with a change in the resource base and high rainfall lead to the collapse of warrens.

Individual behaviour and reproductive success of the species is followed by radio-tracking sub-samples of females. This is done to help explaining the behaviour of the population over time in space. Rabbits have been caught in poor and rich conditions and tracked using fluorescent dye and an ultra-violet light to estimate their foraging radius and thus to establish their area of impact during changing environmental conditions.

From analysis of the habitat selection of the species it has become evident that there is more segregation than expected when looking at land classes and soil types. These relationships are being modelled to determine grazing pressure in association with estimates of vegetation resources. The variations in the resource base in the study area over time, quantity and quality of vegetation have been assessed using a wheel-point device along about 40 km of transects to determine the vegetation cover on a seasonal basis and by looking at the survivorship of plants using Quicktake digital photography of randomly selected plots along the same transects on a six-weekly basis. In addition vegetation is assessed fortnightly on grazed and ungrazed plots in two of the paddocks using digital photography. Precise estimates of resource use have been gained by monitoring vegetation plots and water troughs by 24-hour time-lapse video observations.