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SUSTAINABLE GRAZING IN THE CHANNEL COUNTRY FLOODPLAINS

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SUSTAINABLE GRAZING IN THE CHANNEL COUNTRY FLOODPLAINS. A TECHNICAL REPORT ON FINDINGS BETWEEN JUNE 1999 AND AUGUST 2002[1]

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ABSTRACT

The project "Sustainable Grazing in the Channel Country Floodplains" was initiated by the cattle industry to document the current knowledge of the Channel Country, to address gaps in existing research and to ensure the use of sustainable grazing practices within the floodplains. The Natural Heritage Trust, Meat and Livestock Australia, cattle producers and state agencies provided funding between 1998 and 2002. Current knowledge was documented through 39 members of the grazing community contributing a total of 641 years combined experience of natural resource management. Seventeen on-going soil and pasture monitoring sites provided detailed soil moisture and nutrient levels as well as pasture yield and nutrient levels. This information has led to the development of prototype tools to enhance natural resource management decisions. The publications resulting from this work have allowed land managers new to the Channel Country to quickly understand the accepted industry management practices. The knowledge documented within the project is also of interest to the broader community who have a desire to better understand Lake Eyre and its major river systems, and who wish to ensure the sustainable management of the unique natural resources within the Channel Country.

EXECUTIVE SUMMARY

The project "Sustainable Grazing in the Channel Country Floodplains" was initiated by the cattle industry to document the current knowledge of the Channel Country, to address gaps in existing research and to ensure the use of sustainable grazing practices within the floodplains. The project was funded by the Natural Heritage Trust (NHT), Meat and Livestock Australia (MLA) and the Department of Primary Industries (DPI), with strong support and assistance from industry (including S. Kidman & Co, Stanbroke Pastoral Company, Australian Agricultural Company, the North Australia Pastoral Company, private pastoral companies and private individuals), other government agencies (including Natural Resources and Mines and the South Australian Department of Water, Land and Biodiversity Conservation) and the Lake Eyre Basin Coordinating Group.

Two key DPI publications "Managing the Channel Country Sustainably: Producer's Experiences" (by Vince Edmondston) and "With Reference to the Channel Country: Review of available information" (by Andrew White) were published in 2001. They were widely distributed throughout the Channel Country, and to organisations and individuals with a strong interest in sustainable agriculture. Station managers, policy makers and scientists have found these publications useful, particularly as benchmarks documenting current industry practice and the level of knowledge within the Channel Country.

In addition to documenting current knowledge, the project has contributed new information on the natural resources of the Channel Country. Data collected from 17 flood, soil and pasture monitoring sites established in 1999 have improved the available information on soil chemical and physical properties within the floodplains, which will have great use in salinity studies currently being undertaken. The amount of moisture the soil can hold, and how quickly (or slowly) this moisture evaporates or is used by plants, is now better understood in the Channel Country than for many other parts of Australia's rangelands.

The rapid growth that plants such as Queensland bluebush and native sorghum demonstrate following floods has been documented through monitoring, as has the speed at which the pasture declines in both quantity and feed quality. The nutrient levels of many pasture plants is better known, with 230 plant samples analysed for energy, protein, Phosphorus and digestibility.

Pasture quantity and quality varied considerably, with peak yields of 7,000 kg/ha of dry matter recorded at one site on the Cooper following the 2000 flood. Nutrient levels ranged from moderate to high immediately following flood events, through to low (and inadequate for animal production) towards the end of 2002. There was little or no pasture growth at sites over the 2001/2002 season, despite reasonable rains in some locations. Yields were as low as 10 kg/ha by August 2002. These observations highlight the variable nature of pasture growth, and hence the ability to carry cattle, on the floodplains. They also emphasize the reliance of floodplain pastures on flood events, rather than rainfall, to initiate pasture growth.

The capacity to predict pasture yields from flood and rainfall events using computer modelling shows promise, but requires more time to capture additional flood events to become reliable as a tool for predicting pasture and cattle productivity. About a third of the project has been conducted during one of the worst droughts on record. Whilst the technical knowledge base has been improved through monitoring one large summer flood (in 2000), the generally dry conditions have limited the ability to monitor a range of vegetation responses.

To date, a winter flood (which grows a different suit of plants than summer floods) has not been monitored. The importance of winter floods may be greater than summer floods, with the highly regarded Cooper clover only growing in the cooler months (roughly April through to August). Cattle growth rates of 1.5 to 1.75 kg/hd/day are often quoted on lush stands of Cooper clover following good winter flood events, compared with an annual average of 0.5 to 0.9 kg/hd/day. Liveweight losses occur during dry periods, such as the 2001-02 drought. At least one winter flood needs to be monitored to ensure a better understanding of the subsequent vegetation response and to provide the capacity to model winter feed.

A number of practical indicators and techniques to assist producers in sustainable management have been developed and are being, or soon to be, tested by the grazing community. For instance, visual palatability estimates have been combined with a technique to estimate the quality and quantity of feed on offer. This quality rank method, once fully developed, will enable the prediction of cattle performance and potential carrying capacities from vegetation photostandards. Visual techniques for the estimation of pasture yield, cover and quality are under development and are due to be tested by the grazing community throughout 2003/04. Plant samples were analysed using both chemical based laboratory plant nutrient analysis and NIRS technology, with NIRS showing promise as an alternative to more expensive laboratory methods. A system to allow Queensland bluebush yields to be estimated was developed and successfully tested. In addition, a technique to separate available feed from the total pasture yield has been developed. A compilation of flood descriptions and rainfall maps and a summary of the flood heights for the major rivers and the Bureau of Meteorology guidelines for flood classes are presented in the main project report.

The cattle industry in the Channel Country will benefit from ensuring cattle production is sustainable and productive. Information from this project will form the basis of best practice guidelines and codes of practice that assist in developing Environmental Management Systems (EMS). It will also provide for informed debate over the future role of grazing within these extensive areas. As well as benefiting current and future managers, the information collected is of interest to the broader community who have a desire to better understand Lake Eyre and its major river systems, and who wish to ensure the sustainable management of the unique natural resources within the Channel Country.

In addition, the knowledge gained should have application to other floodplains and naturally flooded country within Australia, including the Bulloo River of south west Queensland and flooded lake systems and bluebush swamps within South Australia and the Northern Territory.

Whilst industry can begin to see immediate benefits as they develop EMS programmes, it will take a further 3 to 5 years to see benefits through an improved capacity to budget for cattle production based on both available and predicted feed on offer. This will depend on improving the scientific capacity in, and accuracy of, computer software which models pasture growth in response to flood and rainfall events. The accuracy of these models can only be improved through further field data collection and monitoring of pasture growth responses.

The project has benefited from strong on-going industry support and involvement. A steering committee (with representatives from Stanbroke, AA Co, NAPCO, Kidman, private landholders, MLA and government agencies) oversees the project and helps set priorities and the direction of research. Over 80% of Channel Country properties with floodplain pastures contributed to "Managing the Channel Country Sustainably: Producer's Experiences" and 36% are direct project co-operators through hosting monitoring sites. A newsletter outlining project results and important events is distributed to all land managers within the Channel Country, as well as to other interested stakeholders.

PROJECT BACKGROUND AND INDUSTRY CONTEXT

The Channel Country of South Australia and western Queensland comprise a mix of country types – from floodplains up to 65 km wide, ephemeral lakes and claypans, to Mitchell grass downs, mulga and spinifex country (Figure 1). The flooded country is the most productive cattle grazing country, with growth rates in excess of 2 kg/hd/day recorded under ideal conditions (Edmondston 2001). The floodplains have also attracted the greatest public and conservation interest, with specific areas now set aside for tourism and conservation uses only and large areas under RAMSAR listing (e.g. Innamincka reserve, White 2001). The bulk of current research efforts are also directed towards conservation issues. The prime focus has been to foster an understanding of the response of algal, bacterial and vertebrate (birds and fish) and invertebrate responses to both flood and drought events (e.g. Bunn and Davies 1995, 1999).

The concept for the “Sustainable Grazing in the Channel Country Floodplains” project originated from the major pastoral companies and the proposal was developed in consultation with Queensland and South Australian Government Departments and community groups. It seeks to enhance the knowledge of, and to ensure sustainable cattle production on, the Channel Country floodplains.

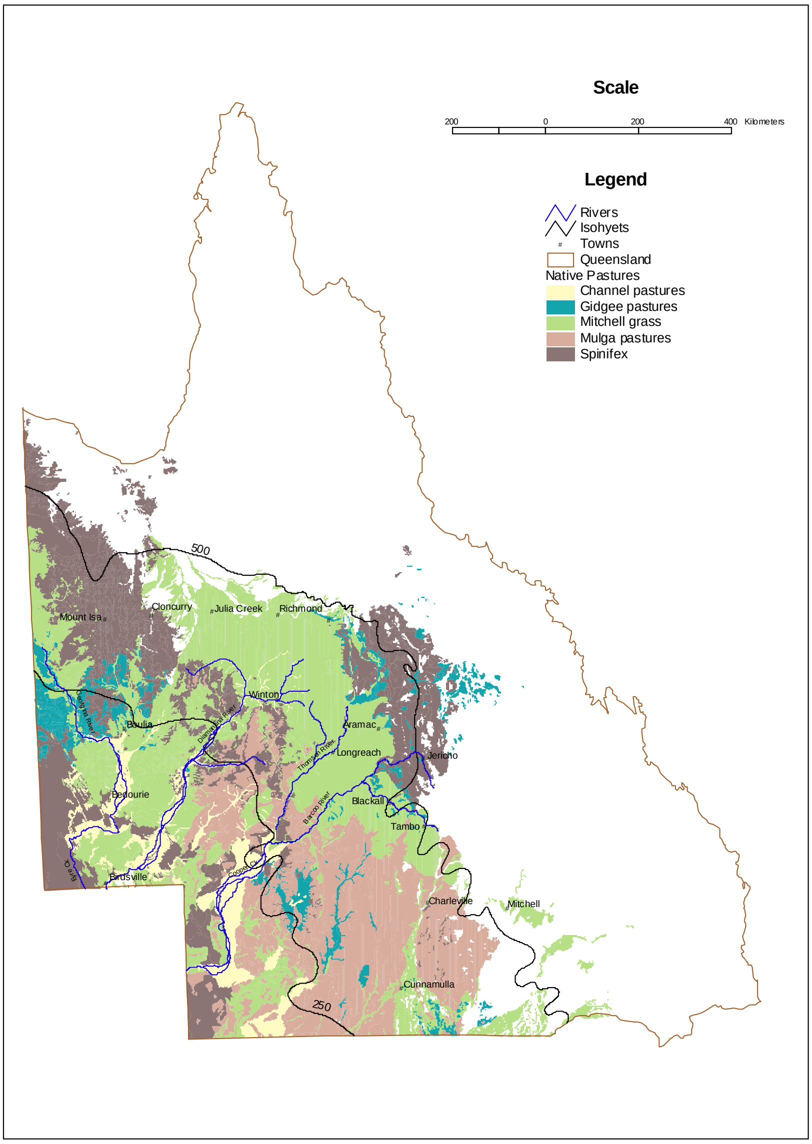


Figure 1. The major pasture communities of western Qld.

Biophysical description of the Channel Country

The area referred to as "The Channel Country" lies exclusively within the Lake Eyre Basin of western Qld and South Australia, with the Georgina and Diamantina Rivers and Cooper Creek the major river systems (Figure 2). Whilst the Thompson and Barcoo form the Cooper at Windorah, neither are considered to have "true" Channel Country; although there are areas of flat floodplain which substantially benefit from flood events in both of these, and other rivers. The Bulloo River, which lies outside of the Lake Eyre Basin, is possibly the most similar to true Channel Country, whilst in the Northern Territory there are similarities with flooded lake systems of the Barkly Tableland.

The Channel Country is dependant on natural flood irrigation events for cattle breeding, growing and finishing operations involving an estimated 0.5 to 1 million head, reportedly turning off in excess of $150M worth of beef annually. The Australian Channel Country bioregion defined by IBRA totals 611,100 km^2 (White 2001), of which 207,600 km^2 in defined as floodplains (Graetz 1980). These same areas contain a number of wetlands of national significance and are characterised by high natural salt levels, sediment loads and wind-borne sand movement. Ensuring grazing practices are sustainable will help to ensure the fine ecological balance of the rivers and wetlands of the Channel Country is maintained.

Pasture communities of the Channel Country

The five main pasture communities present in the Channel Country, in order of area within western Queensland, are:

1. Mitchell grassland (30 million ha)
2. spinifex pastures (21.2 million ha)
3. mulga woodland (19.1 million ha)
4. Channel Country floodplain pastures (5.4 million ha)
5. gidyea (including Georgina gidyea) woodland (4.8 million ha)

The pastures in what is known colloquially as the "outside" country (the non-floodplain areas) are dominated by deep-rooted perennial grass and perennial browse species, with some perennial and annual herbage. Pasture production in these areas of the Channel Country is influenced primarily by local rainfall. Across much of the region, annual rainfall averages less than 175 mm per year, but is subject to wide variation. Rainfall effectiveness is also influenced by time of year and temperature regimes at time of occurrence.

Floodplain pastures are dominated by shallow-rooted annual herbage and grass species, with some deep-rooted perennial shrub species such as Queensland bluebush (*Chenopodium auricomum*) and lignum (*Muehlenbeckia florulenta*). Both localised rainfall and floods influence pasture production on the floodplains. Floods may arise from rainfall in the immediate area (localised floods) or, typically, from rainfall many hundreds of kilometres away. Local rainfall can also increase the growing period of pastures on the floodplains as the floodwaters recede.

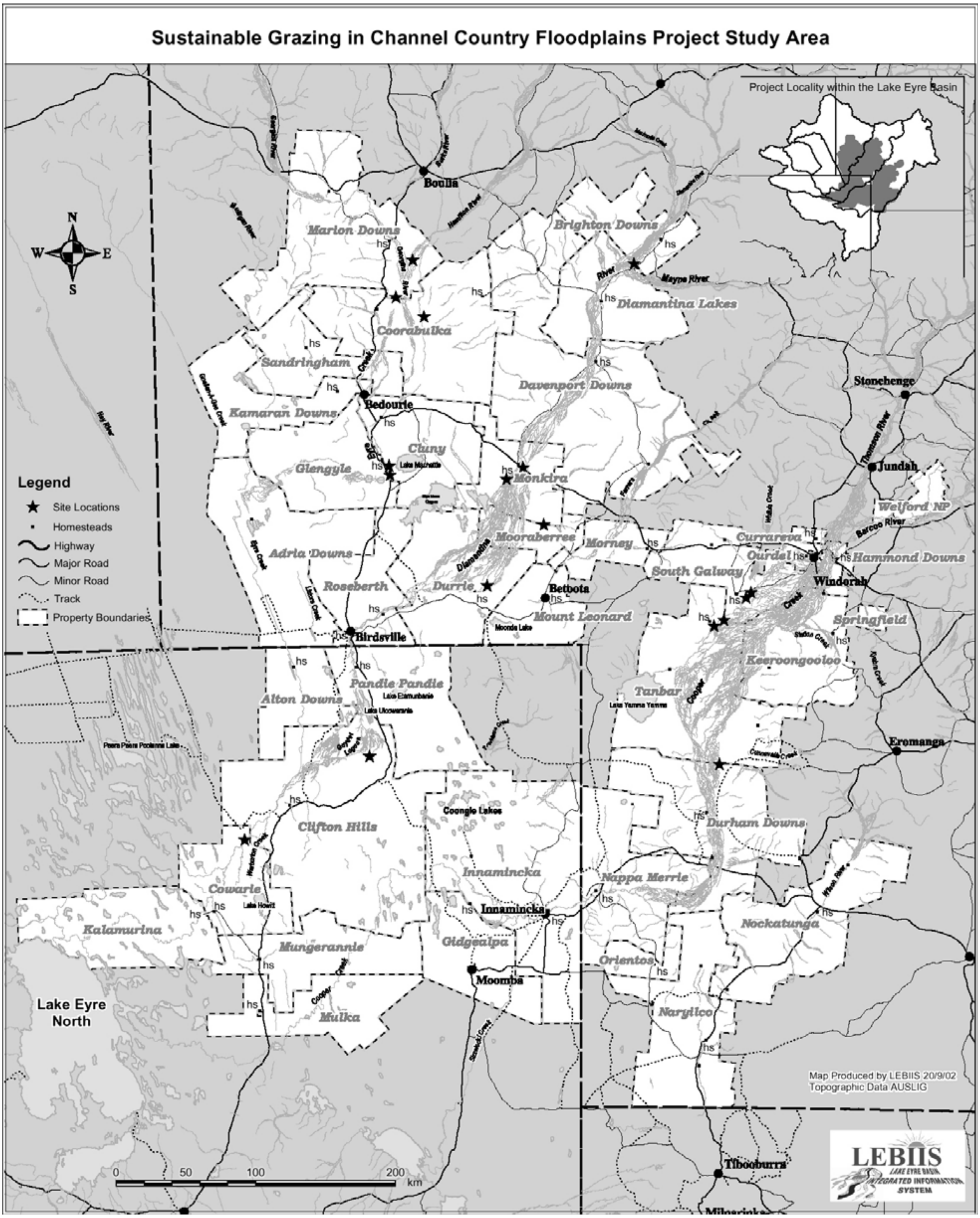


Figure 2. The project study area covers the extensive floodplain systems within the Lake Eyre basin, with sites spread across the major floodplains.

Mitchell grasslands

The Mitchell grasslands are treeless, or sparsely timbered, and occupy cracking clay soils where average annual rainfall is between 200 and 550 mm (Figure 1). Average annual rainfall decreases from the east to the west (Weston 1988) and is highly variable, affecting both pasture yield and composition (Orr 1975).

The dominant perennials in these pastures are the desirable Mitchell grasses (*Astrebla* spp). Within the Channel Country, Barley Mitchell grass (*A. pectinata*) is dominant on pebbly clay soils. Queensland has 30 million ha of Mitchell grasslands (almost 20% of the native pasture in the state) with the capacity to depasture 2.1 million head of cattle, or 17% of Queensland's total carrying capacity (Tothill and Gillies 1992). The Mitchell grasslands have the fourth fastest cattle liveweight gains from native pasture in Queensland (estimated annual average of 0.43 kg/hd/day), or the potential to produce a total of 306,000 t of beef each year (Weston 1988).

Mulga woodlands

The mulga (*Acacia aneura*) tree is a feature of much of Australia's arid interior, occupying 200 million ha of relatively infertile sand or loam soils (AUSLIG 1990). The 19.1 million ha in Queensland is mainly restricted to the south-west corner, but does extend to the north and east of Charleville (Weston 1988). Mulga often forms a dense overstory limiting the pasture underneath to relatively low yields. The leaf of mulga is generally well regarded as a drought fodder (Murray and Purcell 1967). Both sheep and cattle are grazed in the mulga lands, although carrying capacity is relatively low at 40 ha per Animal Equivalent (AE, generally accepted to be equivalent to a 450kg steer) as are cattle growth rates (annual average 0.30 kg/hd/day) (Weston 1988).

Gidyea woodland

Gidyea (*A. cambagei*) occupies approximately 4.8 million ha in Queensland, including the closely related Georgina gidyea (*A. georginae*). Georgina gidyea is the most common gidyea found throughout the Channel Country, and is associated with western rivers such as the Georgina (Weston 1988). Much of central western Queensland's gidyea has been cleared and sown to buffel grass pasture (*Cenchrus ciliaris*), leading to higher carrying capacities and cattle growth rates. Gidyea is found in a thin arc stretching from New South Wales through to the gulf country of Queensland, often in the margins between Brigalow (*A. harpophylla*) woodlands in higher rainfall areas and Mitchell grasslands in lower rainfall areas. Gidyea is usually found on clay soils, although it can grow in loams, earths and duplex soils. The recorded carrying capacity for cleared gidyea is high at 12 ha per AE, as are annual average cattle growth rates at 0.45 kg/ha/day (Weston 1988). Uncleared gidyea is generally regarded as low productivity country, growing sparse pastures of low yields. There is little development potential for Georgina gidyea.

Spinifex pastures

Spinifex (*Triodia* spp and *Plectrachne* spp) pasture occur either as a naturally open grassland, or as an understorey within eucalypt and acacia woodland. Spinifex pastures generally grow in infertile acid sand, loam or duplex soils (AUSLIG 1990) throughout much of Australia's dry interior. In Queensland spinifex pastures occupy 21.2 million ha, occurring to the north west and south east of Mt Isa, on residual outcrops around Winton, the eastern edge of the Simpson and Sturt Stony Deserts, and to the north and south of Barcaldine in the central west. Cattle growth rates and carrying capacities are generally low, with large areas of spinifex in central Australia un-grazed. In Queensland, spinifex is often grazed only in conjunction with other pasture communities, or reserved as drought fodder.

Channel Country floodplain pastures

Channel pastures comprise 5.4 million ha of anastomosing channels, major watercourses (such as the Georgina, Diamantina and Bulloo Rivers and Cooper and Eyre Creeks) and flood out areas in the south west of Queensland (Figures 1 and 3). Coolabah (*E. coolabah*) and river red gums (*E. camaldulensis*) are the major trees lining the watercourses, with Queensland bluebush (*Chenopodium auricomum*) and lignum (*Muehlenbeckia florulenta*) common in depressions and run on areas. A number of grasses (such as rat's tail couch, *Sporobolus mitchellii*), chenopods (such as burrs, *Sclerolaena* spp.) and other dicotyledons (such as cow vine, *Ipomoea lonchophlla*) respond to the irregular flooding along the lower catchment. Cattle growth rates are the best quoted by Weston (1988) for native pasture in Queensland, averaging an estimated 0.50 kg/hd/day, although carrying capacity is relatively low at 40 ha per AE.

Channel Country floodplain and river systems are unique in a number of ways, including:

- The high levels of grazing potential within an otherwise arid to semi-arid landscape
- Cooper Creek and the Diamantina and Georgina Rivers' physical structure of "braided channels within braided channels" (anastomosing)
- The width of the floodplains (e.g. the Cooper is about 65 km wide to the south of Windorah)
- Internally draining (endoreic) into inland wetlands and lakes (e.g. Lake Yamma Yamma, Lake Eyre)
- Vegetation growth is dominated by annual species dependant on flooding and overland flow, supplemented by growth of the perennial shrub – Queensland Bluebush
- Extremes of climatic variability (e.g. the timing and extent of rainfall and flood events) necessitating long term monitoring

The pasture response of these natural irrigation areas can be substantial both in area and amount, and has been utilised by a variety of grazing enterprises for over 130 years. These areas are the backbone on which the breeding and growing-out operations of the large pastoral companies are based and are also important for smaller locally based graziers. Based on anecdotal evidence alone, it appears that there has been minimal impact on the resource base. This may be especially true for the floodplains, which the experienced managers regard as self-regulating, with cattle generally unable to access floodplain pastures until after seed set. This is, however, unsubstantiated scientifically and requires further investigation.

Channel Country floodplain pastures have been classified into three major, and one minor, Land Systems in Queensland (Table 1) based on the Western Arid Region Land Use Survey (WARLUS) series, which has been published in six parts (e.g. Turner *et al*. 1993, Figure 4). Land Systems comprise a numbered code (eg C1), a descriptive code (eg Cooper) and a description. Flooding frequency, duration, water speed and inundation height differ between these classifications. C1 (Cooper) generally floods more frequently, can be deeper and with faster moving water than C3 (Woonabootra) or C2 (Cunnawilla) as it follows the major river channels (Figure 5). In contrast, C2 floods the least frequently and for the shortest duration, has the lowest water depth and slow water speed as it occurs the furthest from major channels, or as higher areas if close to major channels. C3 tends to have an intermittent flooding frequency, with variable water speed and inundation, but tend to have the longest flooding duration, as it occurs as low lying swamps and depressions.

Land System numbering and descriptions are rarely standardised across WARLUS boundaries (Figure 4), leading to difficulties in interpretation on the regional scale. For instance, C1 (Kendall) occurs only in Part V of the WARLUS series, located to the north of Windorah along the Thomson River. C1 (Kendall) within Part V bears some resemblance to C1 (Cooper) within Parts I, II and VI, but is not necessarily equivalent. There are no floodplain land systems in WARLUS surveys to the east of Quilpie (Parts III and IV, Figure 4).

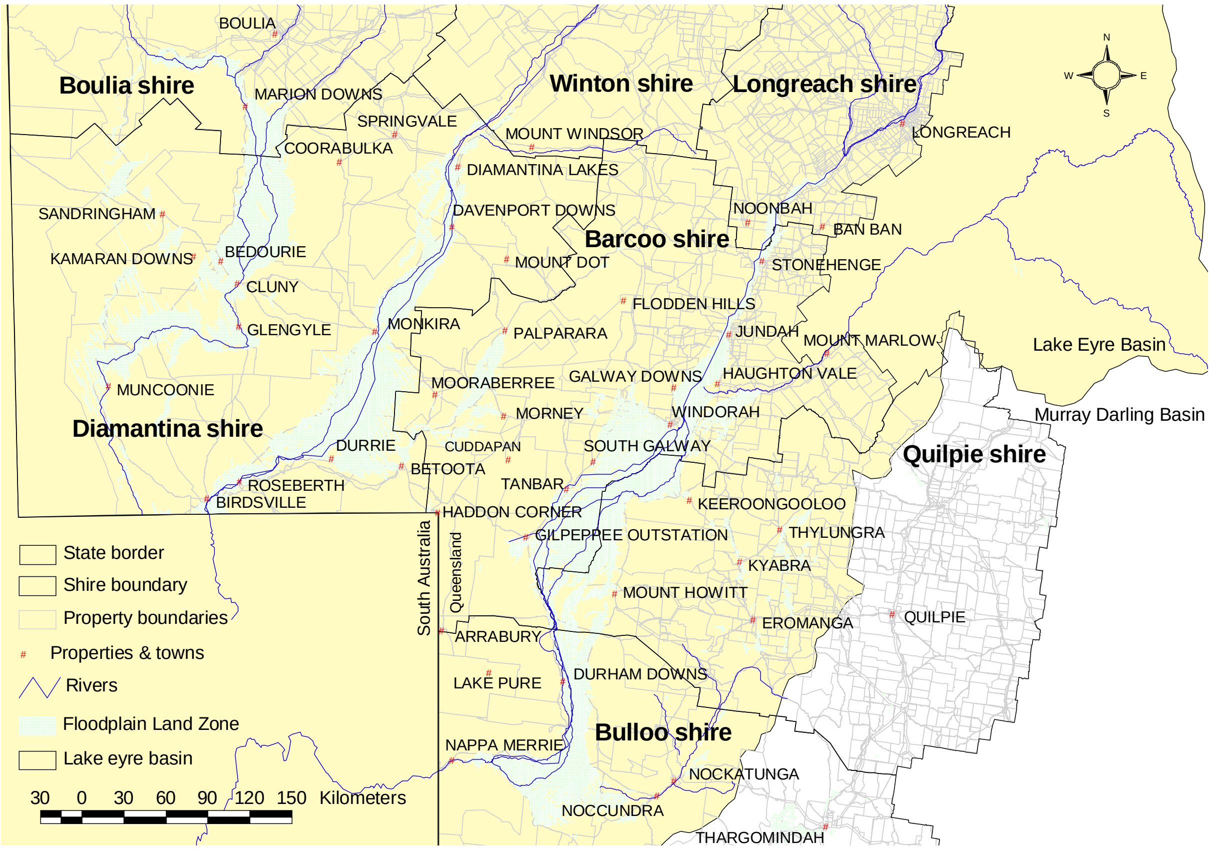


Figure 3. The extent of Channel (floodplain) Land Systems in Queensland in relation to Local Government Areas (shire boundaries).

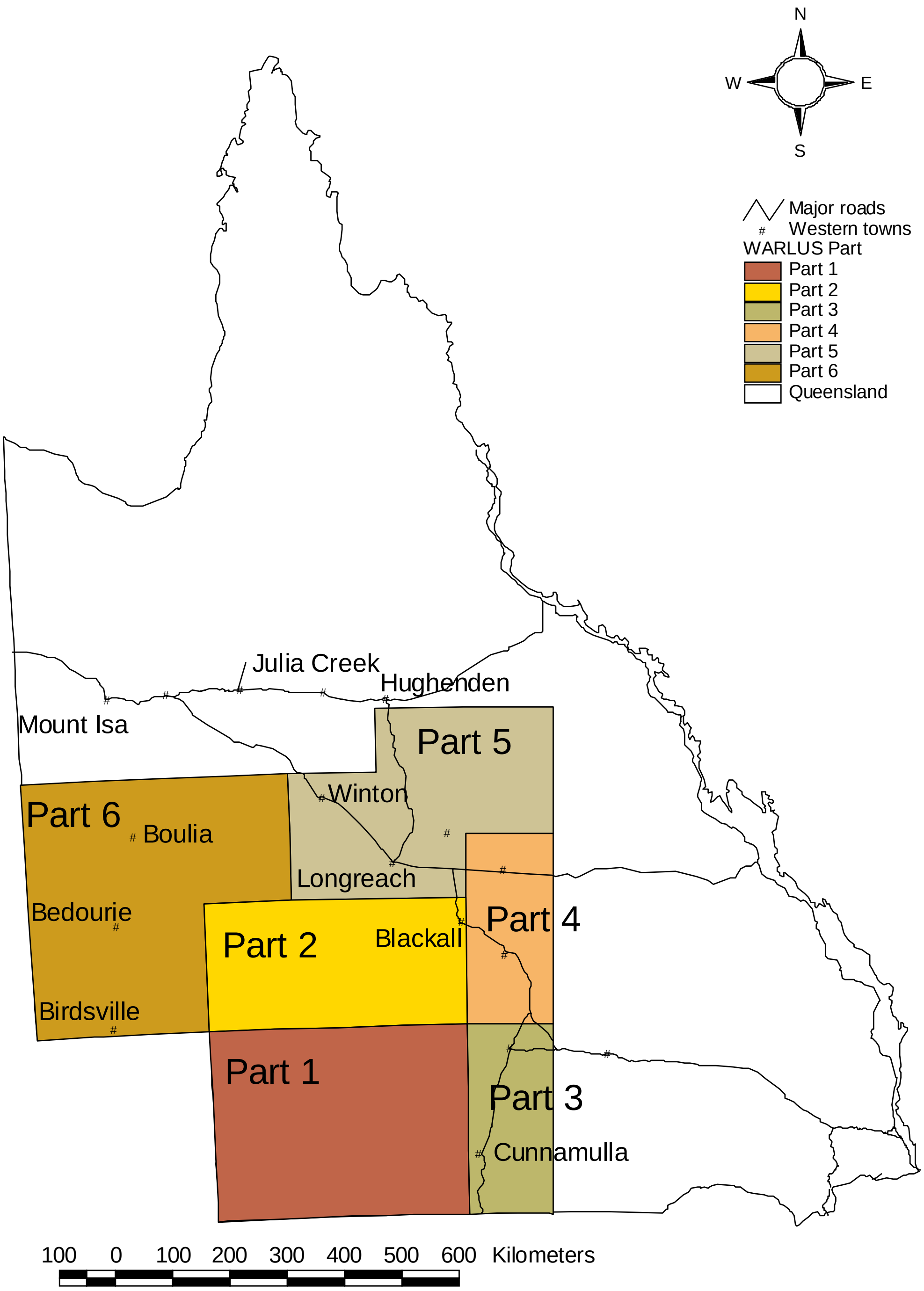


Figure 4. The location of WARLUS study areas within Queensland.

Table 1. Channel Country Land System descriptions (modified from Turner *et al*. 1993 and Mills 1980) indicating the distribution of experimental sites between river catchments and across Land Systems.

Land System	Vegetation description	Flooding description	Soils description	Number of Sites*		
				C	D	G
Cooper (C1)	To the north, sparse (open) grassland, ephemeral herbland or forbland, with Queensland bluebush/lignum low open shrubland in depressions, and coolibah, lignum/belalie, gooramurra shrubby (low) open woodland on major channels; grading into coolibah/lignum low open woodland on major channels, and river red gum/coolibah low open woodland to open woodland on main channels to the south	Frequently flooded alluvial plains with anastomosing channels, often with deep and fast moving water associated with major channels	Very deep, grey cracking clays	3 (2b, 1l)	4 (2b, 2l)	3 (1b, 2l)
Cunnawilla (C2)	Ephemeral sparse (open) herbland, grassland, forbland or saltbush/bassia/short grass herbfield, with coolibah/lignum shrubby low open woodland along minor channels	Occasionally flooded, flat alluvial plains, generally with shallow and slow moving water, occurring the furthest from major channels	Very deep, crusted, brown and grey cracking clays subject to scalding	1	2	1
Woonabootra (C3)	Queensland bluebush herbaceous low open shrubland and lignum low open scrub with coolibah, lignum, belalie, gooramurra shrubby low open woodland on larger channels and ephemeral herbland and forbland sparsely wooded with coolibah, with areas of swamp canegrass low open shrubland to the south	Poorly drained swamps and depressions on alluvial plains (often channelled) intermittent flooding frequency, with variable water speed and depth	Very deep, poorly drained, weakly gilgaied grey cracking clays	1	1	1
Kendall (C1 in WARLUS Part V, north of Windorah)	Predominantly short grasses with bluebush, lignum low open-shrubland in depressions to coolibah, river red gum, belalie, gooramurra, lignum shrubby open-woodland fringing the channels and deep waterholes	Flooded alluvial plains with anastomosing channels;	Deep grey cracking clays.	0	0	0

*C = Cooper Creek, D = Diamantina River, G = Georgina River; b = bluebush, l = lignum sub-categories

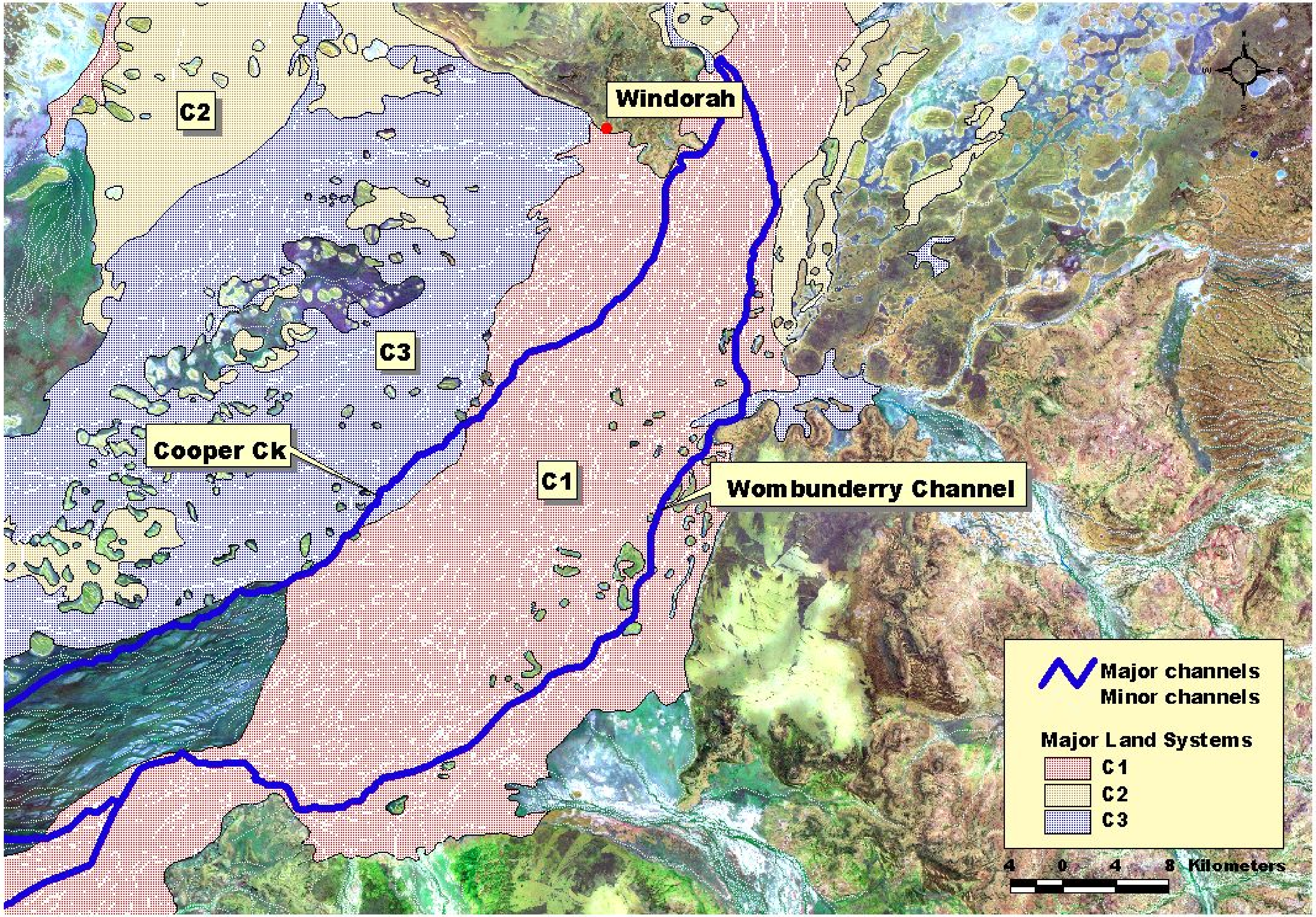


Figure 5. An example of the locations of C1, C2 and C3 Land Systems relative to a major river channel, in this case Cooper Creek south of Windorah. Land Systems are shown overlaying a satellite image (Landsat TM) from mid 1995.

Industry Context

Cattle production systems and property management

Cattle production in the Channel Country of south-west Queensland, north-east South Australia and the southern Northern Territory occurs in two distinct production systems – the rain fed non-flood areas and the naturally irrigated flood areas. Levels of cattle production throughout various seasons and time periods are influenced by a combination of factors, including the management of the combination of the two land system areas, the breed, class or classes of cattle being run on individual properties, and the management of the cattle on the properties or within property amalgamations and ownership structures.

Cattle production systems on properties within the Channel Country is highly variable with individual properties varying from full system breeder/finishing operations to dedicated grow-out properties with finishing of cattle for markets taking place outside the Channel Country. Ownership ranges from individual, privately owned properties, to pastoral companies with a series of holdings. The importance of the ownership structure is in the flexibility of managers/owners to respond to changes in pasture conditions whilst maintaining production. A significant proportion of the cattle grown out or finished in the Channel Country are brought into the area each year, either as a result of inter-property transfer within companies or through sales.

Cattle vary from straight bred *Bos taurus* breeds including Shorthorn and Hereford, *B. taurus* x *B. indicus* crossbreeds and straight-bred *B. indicus* (Brahman) breeds. The cross-bred and high content *B. indicus* cattle tend to be bred outside the Channel country and moved into the area for finishing, while the *B. taurus* cattle are primarily bred in the area.

Industry Profile

The Channel Country in Queensland is almost exclusively Pastoral Holding lease, with leases held by private individuals, private companies and pastoral companies, some of which are publicly listed and others in private ownership. The area was pioneered by a number of prominent pastoral families, including the Duracks, Costelloes, Kidmans, Duncan-Kemps and Tullys. Descendents of these families are still present in the region, either with continued family property ownership, or as managers for the larger pastoral companies. There are also many families who have maintained three to four generations of landholding within the Channel Country, including the Kidd family of Windorah, the Mortons of Birdsville and the Oldfields of South Australia.

Many of the original family properties have been bought by pastoral companies, or converted to family companies. Of the top 10 beef producers in Australia, seven have Channel Country holdings with substantial areas of floodplains (Table 2).

For instance, Stanbroke Pastoral Company (Stanbroke), which runs the floodplain holdings of Davenport Downs, Tanbar, Nappa Merrie and Bulloo Downs, was Australia's leading beef producer in 2001 (by turn-off), producing 36 207 tonnes of beef (Table 2). They are also Australia's largest landowner (13.4 million ha across 27 properties) and the largest cattle producer (551 351 head), employing a total of 440 staff throughout Australia.

S. Kidman & Co (Kidman), have the largest number of Channel Country holdings, with Sandringham, Glengyle, Durrie, Morney Plains, Mooraberree, Durham Downs, Naryilco and Innamincka Station within their portfolio of 13 properties (Table 2).

Australian Agricultural Co (AA Co) with Brighton Downs and South Galway, North Australia Pastoral Company (NAPCO) with Marion Downs, Coorabulka and Monkira, Consolidated Pastoral Company (Consolidated) with Nockatunga and Colonial Agricultural Company (Colonial) with Keeroongooloo, are the other major pastoral companies with floodplain areas within their Channel Country holdings. The major family companies of Arrabury Pastoral Company (the Daley family) with Cluny and Mt Leonard/Arrabury, and Brook Proprietors (the Brook family of Birdsville) with Kamaram Downs Alton Downs and Adria Downs both have substantial floodplain areas. McDonald Holdings (MDH) have two

Channel Country properties adjoining the Diamantina and Mayne Rivers (Mt Windsor and Verdun Valley), but have no true floodplain country. Santos, with primary interests in the extraction of oil and gas, also own the properties Nappa Merrie and Gidgealpa within the Channel Country but have these sub-leased to pastoralists.

Table 2. The major beef producers with Channel Country holdings.

2001 national ranking	Organisation	turn-off (t)	herd size (head)	land holding ('000 ha)	total property number	staff number
1	Stanbroke Pastoral Company	36,207	551,351	13,400*	27	440
2	Australian Agricultural Co	33,865	408,092	6,530	18	350
3	S. Kidman & Co	13,742	168,000	11,190	13	190
4	North Australia Pastoral Company	12,955	188,000	5,707	14	170
5	Consolidated Pastoral Company	12,463	242,000	5,225	17	130
7	Colonial Agricultural Company	8,359	128,277	2,018	8	73
10*	McDonald Holdings	N/a	130,000*	3,370*	12	N/a
16	Brook Proprietors	2,820	30,700	2,907	4	34

source: Anon 2002 and *2001

The major pastoral companies employ rangeland or environmental officers to enhance sustainable management through developing practical management tools and implementing EMS programs. The Channel Country is also home to the innovative organic beef company, OBE beef. Both of these aspects of the industry demonstrate a genuine desire to manage the land both profitably and sustainable, and indicate a willingness to adapt management to suit the latest scientific findings as well as to suit current environmental conditions. A large proportion of the company managers have extensive experience within the Channel Country, although a number of new managers have also taken the helm in recent years.

Project Consultation

This project originated from the pastoral companies and the proposal was developed in consultation with Queensland and South Australian Government Departments and community groups. Consultation with Stanbroke, AA Co, Kidman and NAPCO, and with private pastoral managers has been extensive, frequent and ongoing, and has encouraged their continued interest and support. Pastoral company representatives have been involved in defining the project, setting the goals, and deciding on the experimental techniques to be used. On-ground property managers and Landcare managers have been involved in selecting suitable exclosure locations and for assisting with assessments.

A steering committee comprising representatives of the four major grazing companies with Channel Country holdings (Stanbroke, AA Co, NAPCO, and Kidman), private landholders, the Lake Eyre Basin Coordinating Group, Meat and Livestock Australia and Queensland agency staff was formed in late 1999 (Appendix 1). The role of this committee is to provide practical advice and oversee project direction to ensure industry and community goals are met.

The steering committee had expressed a need for the continuation of research and monitoring in the longer term (a minimum of 10 to 15 years overall) to try and capture the extreme variability encountered within the Channel Country. The initial issues expressed by the steering committee were:

- Little factual information is available on the soil moisture, nutrient levels and vegetation response following different flood events during different seasons and different conditions

- Previous experiences and management practices have not been compiled into a reference to highlight the evolution of current management

- There is no documentation of the grazing management practices currently used which are believed to be appropriate for this pasture

- There is little factual data available on the effects on the resource base and the economics of the variety of current grazing practices

- No reference material on plant species or management practices specific to the Channel country is currently available to assist managers

Sustainably grazed eco-systems are needed in these areas to ensure the longevity of the both the unique natural resources and the valuable cattle grazing industry. Both private land holders and pastoral companies have strongly indicated the desire to know if their current grazing practices are sustainable, what practices (if any) need changing to ensure sustainability and how current sustainable practices can be documented and promoted. One of the key issues at the start of the project was the lack of documented scientific evidence demonstrating sustainable practices, or the need for improvement.

Even now, following 3 years research, there is insufficient evidence to determine the impacts of grazing within the floodplains, or to make recommendations on potential changes to grazing practices. The research to date has highlighted the extreme variability of the Channel Country – from a major flood during the summer of 2000 through to the drought conditions currently experienced. This, in turn, has highlighted the continued need for monitoring the flood events, pasture response and subsequent health of the floodplains in relation to cattle grazing.

Impacts

The data collected on both the environment and the grazing systems will continue to ensure the long-term survival of grazing as a viable and environmentally sound industry within the Channel Country. It will enable the industry to be proactive in promoting itself as productive, profitable, sustainable and environmentally friendly. If, in the future, alternative industries are proposed for the floodplains, or the impact of grazing is questioned, it will also provide valuable information for promoting grazing as being the most appropriate and best use of the floodplains.

Social impacts

This knowledge gained from this project has the potential to provide positive social outcomes such as maintained employment opportunities (for both indigenous and non-indigenous Australians) and maintained services to small rural communities as a follow-on from improved cattle productivity and continued sustainable natural resource use.

The Channel Country of Queensland is administered by the shires of Boulia (administrative centre Boulia), Diamantina (administrative centre Birdsville), Barcoo (administrative centre Jundah) and Bulloo (administrative centre Thargomindah). The western Section of the Quilpie shire extends to the Cooper Creek floodplains. Small areas of floodplain Land Systems also occur within Longreach and Winton shires (Figure 3).

The combined shires of Boulia, Diamantina, Barcoo and Bulloo had a population of 1828 persons on 30 June 2001, with a projected decline to 1554 in 2021. Of these, 337 were indigenous Australians. Agriculture employs 463 people (48.5% of the working population) across these shires and grossed $64.6 million in the 1998-99 financial year for livestock (cattle) products and disposals (OESR 2001).

These statistics indicate that the population base, and hence the social fabric, of the Channel Country is largely dependent on cattle grazing. Both pastoral companies and private landholders play their role in maintaining this social fabric. For example, Stanbroke Pastoral Company (Australia’s largest landowner – 13.4 million ha - and cattle producers – 551,351 head) employ a total of 440 staff throughout Australia.

An estimated 250 to 300 people are employed in the Channel Country between the four major cattle companies of Stanbroke, AA Co, Kidman and NAPCO. Consolidated, Colonial and private companies and individuals also employ numerous people within the Channel Country’s cattle industry. Most of the companies operate formalised Equal Employment Opportunity and Affirmative Action programs within their workplaces, with family properties and companies generally operating informal programs. Of particular interest from a land management and cultural perspective, is that these programs continue to ensure employment, training and promotional opportunities for Aboriginal people.

The social well being of these remote areas is dependent on sustainable grazing of the natural resources. Furthermore, tourism development has been built on the back of the cattle grazing industry as well as the natural state of the environment and well-preserved landscapes. The romanticism of the efforts of grazing pioneers such as the Durack family and Sir Sidney Kidman are intrinsically linked to the promotion and success of tourism throughout the Channel Country.

Environmental impacts

This project has begun to deliver positive environmental impacts through ensuring the sustainable grazing of the Channel Country floodplains. Potential downstream impacts include maintaining the health of Lake Eyre, other major lakes (e.g. Lake Yamma Yamma) and waterholes that act as refuges for vertebrates, invertebrates and their food sources. This will be achieved by ensuring grazing management practices that maintain natural levels of ground cover and vegetation structure, allowing for natural water flows and natural levels of sediment transport.

Economic impacts

An estimated 0.5 to 1 million head of cattle are run in the Channel Country of Queensland, with a recorded gross turn-off value of $64.6 million in the 1998-99 financial year. Turn-off following major flood events, such as in 2000, is reputedly in excess of $150M worth of beef.

Even small improvements in the efficiency of production, or increases in animal numbers, can have significant economic impacts. A 5% gain, for instance, would provide a further $3.2 million per annum (based on an annual turn off of $64.6 million). It is possible that gains in the order of 10 to 30% ($6.4 to 20 million) are possible under current management practices. Improvements in the ability to predict flood induced pasture growth, pasture quality and animal performance will provide individuals and companies with opportunities to respond more quickly to flood events, and make use of available feed without fear of damaging the natural resource base. Consequently, this project has the potential to deliver between $3 and $20 million worth of improved cattle production per annum, but more flood and rainfall events need to be monitored to develop practical tools to realise this potential.

There are potential benefits through utilising the information gained to date through EMS (environmental management systems) which can lead to improved marketing opportunities or facilitate reporting mechanisms to the public or shareholders of listed companies. These benefits can include the ability to promote an adherence to the leaseholder’s duty of care or to upholding environmental standards.

Public and private benefits

Environmental and flow-on social benefits of this project are entirely public benefits. Economic benefits are a mix of public and private – improved cattle production will increase the gross value of production for private individuals and pastoral companies. However, this is the driving force for the flow-on social benefits, which cannot proceed in isolation.

Additionally, increases in the gross value of production will be equally accessible by all land holders within the Lake Eyre Basin through the publication and release of project results and products.

PROJECT OBJECTIVES

This technical report relates to the objectives of two “Sustainable Grazing In The Channel Country Floodplains (SGCCF)” NHT projects (972625 and 2012630) and to the objectives agreed to with Meat and Livestock Australia for additional funding within the project “Sustainable Grazing In The Channel Country Floodplains (SGCCF)” (NAP3.227).

The objectives of the initial NHT project (972625) were to:

1. By community consultation document the existing knowledge of flood responses and floodplain management
2. Improve technical knowledge of floodplain vegetation response by monitoring at selected study sites
3. Describe vegetation response in terms of palatability, nutrition, species richness and carrying capacity
4. Develop and promote practical indicators and techniques to assist producers in sustainable management
5. Promote and extend the range of sustainable management practices and best practice grazing systems
6. Compile and publish the literature review and the community consultation data
7. Produce and publish “Managing Grazing in the Channel Country”
8. Produce and publish “Plants of the Channel Country”

Additional, or altered, objectives within the second phase of the project (2012630) were to:

- Compile and publish the community consultation data as “Managing the Channel Country Sustainably-Producer’s Experiences”
- Compile and publish the literature review
- Produce and publish “Plants of the Channel Country” in association with the Channel Landcare Group

The objectives of the MLA sponsored project were to substantially enhance the project through:

1. Collect and document the existing scientific and experiential knowledge of the ecology and grazing management practices of the Channel Country (no MLA funds provided).
2. Develop and enhance the limited scientific knowledge of the ecology and response of the Channel Country vegetation and soils to flooding events.
3. Develop and enhance the limited technical knowledge of the effects of current grazing practices.
4. Identify, refine and produce tools for use in decision making for managing grazing of the natural pastures.
5. Extend best practice to industry (a new objective through MLA and NHT funding).
6. Enhance communication between and within industry, the public and the scientific community.

SUCCESS IN ACHIEVING OBJECTIVES

Success in achieving project objectives is reported on the basis of the original NHT objectives. The relevant MLA objective is listed within each of the eight NHT objectives. Any alterations to the original NHT objectives during the second phase of NHT funding are also listed under the original objective. The MLA portion of the project is still progressing, with funding anticipated to continue into 2006 or beyond to ensure a variety of flood and rainfall events are monitored.

Objective 1. By community consultation document the existing knowledge of flood responses and floodplain management

The existing knowledge of flood responses and floodplain management has been documented through the publication of “Managing the Channel Country Sustainably. Producers’ Experiences” by Vince Edmondston (2001). A total of 250 copies have been printed to date, and a third re-print is underway. Every landholder within the Channel Country project area has received a free copy of this book.

“Managing the Channel Country Sustainably. Producers’ Experiences” collated the experience of 39 people actively involved in managing properties from the Georgina and Diamantina Rivers and Cooper Creek through direct interviews. This represented a total of 641 years experience across 30 properties (83% of the total number of grazed properties within the project area, see Figure 2 on page 9).

In addition, a project steering committee was established as part of the MLA funding agreement, with representatives from each of the major pastoral companies, private landholders, state government agencies and MLA. A project newsletter is also distributed to every property within the project area, and also to another 150 interested parties (including scientists, policy makers and land managers, as well as to the general public).

Research is conducted on 13 cooperating properties (36% of the total number of grazed properties within the project area). Ongoing consultation and discussion of results with the managers and owners on these properties, as well as with pastoral company rangeland and environmental officers, further contributes to documenting existing knowledge.

The steering committee and members of the community also contributed to the publication “With Reference to the Channel Country. Review of available information” by I.A. White (2001) through constructive comments during its writing and the provision of many documents. Most notable was the contribution of the scientific community in providing information, maps and otherwise hard to obtain documents (such as internal reports). The mining industry was also actively involved, especially through discussions and the provision of reports, handbooks and geological surveys. The review of literature even managed to unearth a copy of “Channel Country”, an ABC documentary from the 1950s.

Station managers and scientists alike have found the publications useful, particularly as benchmarks documenting current industry practice and the current level of knowledge within the Channel Country.

This objective was linked to the MLA project objective “Collect and document the existing scientific and experiential knowledge of the ecology and grazing management practices of the Channel Country”, and was listed as NHT Objective 6 in the second NHT phase of the project.

Objective 2. Improve technical knowledge of floodplain vegetation response by monitoring at selected study sites

The technical knowledge of floodplain vegetation response to flood and rainfall events has been dramatically improved, but not to the point of enabling on-ground management changes. The 17 flood, soil and pasture monitoring sites established within the floodplains in 1999 have increased the information available to the public and the scientific community.

Soil, the medium though which plants grow, has been characterised for chemical and physical properties.

This may have great use in current salinity studies being undertaken. Sites within the Georgina and Diamantina Rivers showed high natural levels of salts, for instance, whilst Cooper Creek sites did not.

The amount of moisture the soil can hold, and how quickly (or slowly) this moisture is evaporated or used by plants is now better understood in the Channel Country than for many other parts of Australia's rangelands. Soil moisture levels have been monitored to 1 m depth (the deepest that plants, apart from trees, are generally able to extract water from) on 6 to 15 occasions over the reporting period (June 1999 to August 2002) at these sites, depending on flooding and rainfall. Moistures ranged from extremely dry (and unavailable for plant growth) during 2002, to very wet following the flooding of 2000.

Pasture yield, composition and nutritional quality was measured on 9 to 15 occasions, depending on flooding and rainfall. Pasture growth and quality varied considerably, with peak above ground yields of 7000 kg/ha dry matter recorded following the 2000 flood. The lowest yield recorded was 10 kg/ha in August 2002. There was no pasture growth in Queensland over the 2001/2002 season, despite reasonable rains in some locations. These observations serve to highlight the extreme variability where pastures grow from flood events within an arid landscape, and hence the flexibility needed in adjusting cattle numbers on the floodplains. They also highlight the reliance of floodplain pastures on floods, rather than on rainfall.

The rapid growth that plants such as Queensland bluebush and native sorghum demonstrate following floods has now been documented, as has the speed at which the pasture declines in both quality and quantity. The nutrient levels of many pasture plants is better known, with 230 plant samples analysed for energy, protein, Phosphorus and digestibility. Samples were analysed using both chemical based laboratory plant nutrient analysis and NIRS technology to compare the two systems. NIRS shows promise as an alternative to more expensive laboratory methods.

At least a third of the monitoring period has been during one of the worst droughts on record. Whilst the technical knowledge base has improved, the dry conditions have limited our ability to monitor vegetation responses following flood and rainfall events. To date, a winter flood (which provides the lushest feed for cattle production, as well as a different vegetation response, Edmondston 2001) has not been monitored. In effect, this means that more time is required to capture additional flood events, with at least one winter flood needed to ensure a better understanding of the subsequent vegetation response.

Computer modelling of pasture growth was a key aspect of improving the technical knowledge of the floodplain vegetation response. The dry conditions and lack of flood events have restricted the data available for modelling. In general terms, 2-3 flood events would be needed to enable models to be calibrated, with further events allowing for the validation of the models. Nevertheless, limited modelling to date demonstrates that it is technically feasible. This is an important piece of information in itself, as modelling has not been attempted within floodplain systems before. Pasture growth models have generally been developed for areas that rely on rainfall, and are often restricted in terms of the ability to use inputs other than rainfall. In the case of floodplains, however, flood height and period of inundation data will need to be used as the soil moisture input. The demonstration of the capacity to model within flooded systems is thus very encouraging for future research.

More detailed technical information can be found within the Results and Discussion section (pages 41 – 116).

Cooperative research with the University of Queensland and Griffith University has also contributed to improved technical knowledge of floodplain vegetation. Andrew White (project Scientist from 1999 to mid 2001) directly assisted Kiowa Rieck (University of Queensland) in the collection of soil seed bank and pasture samples, whilst Samantha Capon (Griffith University) has discussed project findings and sought advice from members of the project team.

Two theses of relevance have come from this liaison:

- Capon, S. (1999). Zonation of Floodplain Vegetation On a Flood Frequency Gradient In a Variable, Arid-zone Catchment. Bachelor of Science Honours thesis, Faculty of Environmental Sciences, Griffith University, Nathan campus. 59 pp plus appendices.

- Rieck, K. (2000). Preliminary investigation into seed bank dynamics of the Channel Country. Bachelor of Applied Science Industrial placement report. University of Queensland, Gatton. 74 pp plus appendices.

This objective was linked to the MLA project objectives “Develop and enhance the limited scientific knowledge of the ecology and response of the Channel Country vegetation and soils to flooding events” and “Develop and enhance the limited technical knowledge of the effects of current grazing practices” and was listed as Objective 4 in the second NHT phase of the project.

Objective 3. Describe vegetation response in terms of palatability, nutrition, species richness and carrying capacity

Plant nutritional responses have been measured though the analysis of 230 plant samples for energy, protein, Phosphorus and digestibility. Levels ranged from moderate to high immediately following flood events, through to low (and inadequate for animal production) by the end of the reporting period. The highest protein and digestibility levels were recorded in 2001.

Species richness was recorded in both grazed and ungrazed areas in August 2002. There were few discernible differences in either yield or richness. Only one plant species, cow vine, was more prevalent in the absence of grazing.

Palatability estimates have been combined with a technique to visually estimate the quality and quantity of feed on offer. This Quality Rank method, once fully developed, will enable the prediction of cattle performance and potential carrying capacities from vegetation photostandards.

Describing carry capacity *per se* has not been achieved, as this is dependent on achieving sufficient data for effective pasture modelling.

More detailed technical information can be found within the Results and Discussion section (pages 41 – 116).

This objective was linked to the MLA project objectives “Develop and enhance the limited scientific knowledge of the ecology and response of the Channel Country vegetation and soils to flooding events” and “Develop and enhance the limited technical knowledge of the effects of current grazing practices” and was listed as Objective 5 in the second NHT phase of the project.

Objective 4. Develop and promote practical indicators and techniques to assist producers in sustainable management

The successful completion of Objectives 1 to 3 was a prerequisite for the success of subsequent objectives. The failure to meet Objectives 2 and 3 in the entirety (due to the dry conditions, as discussed within Objective 2), has limited the success of Objectives 4, 5 and 7. In each case, however, a successful foundation has been established and the continuation of the project through further funding will see a number of practical tools developed.

A number of practical indicators and techniques to assist producers in sustainable management have been developed and are being, or soon to be, tested by the grazing community.

Visual techniques for the estimation of pasture yield, cover and quality are under development and are due to be tested by the grazing community throughout 2003/04.

A system to allow Queensland bluebush yields to be estimated was developed and successfully tested. In addition, a technique to separate available feed from the total pasture yield has been developed.

This report presents a compilation of flood descriptions and rainfall maps (Table 5) and a summary of the flood heights for the major rivers and the Bureau of Meteorology guidelines for flood classes (Appendix 2).

The publications "Managing the Channel Country Sustainably. Producers' Experiences" and "With Reference to the Channel Country. Review of available information" provide industry with sound base line information for developing best practice guidelines and codes of practice within Environmental Management Systems (EMS).

The capacity to predict pasture yields from flood and rainfall events through computer modelling shows promise, but requires more work to become reliable as a cattle and feed budgeting tool. In particular, winter floods are yet to be documented, with only summer floods experienced to date through the course of the project. The importance of winter floods may be greater than summer floods, with the highly regarded Cooper clover only growing in the cooler months. Preliminary modelling with GRASP suggests that the capacity to predict pasture yields from flood and rainfall events can be achieved over a realistic timeframe of a further 2-4 years.

Initial research into the use of NIRS technology to estimate pasture quality has demonstrated that crude protein levels can be reliably estimated based on current information, but that further work is required for digestibility and metabolisable energy to be reliably predicted. The NIRS technique has the advantages of lower cost, and faster turn-around when compared with other laboratory techniques.

Other potential tools have been discussed or initially tested and may include soil moisture monitoring (either through remote sensing techniques or simple ground based techniques) to assess the likely time period of good quality feed remaining on offer, tools to estimate broad scale grazing impacts (eg through remote sensing), or tools to estimate cattle growth rates in relation to visually assessable pasture quality.

The steering committee has expressed concerns over attempting to provide on ground management guidelines and advice from short-term results within the high variably of the Channel Country. Their recommendation has been that there is insufficient data to date to produce decision-making tools.

This objective was linked to the MLA project objective "Identify, refine and produce tools for use in decision making for managing grazing of the natural pastures" and was listed as Objective 3 in the second NHT phase of the project.

Objective 5. Promote and extend the range of sustainable management practices and best practice grazing systems

This objective has been met through enhanced communication (MLA Objective 6), through collecting and documenting existing knowledge (MLA Objective 1) and through extending best practice to industry (MLA Objective 5).

Enhanced communication has been comprehensively met through a wide variety of methods and products to enhance communication between and within industry, the public and the scientific community including:

- A planning meeting held at the beginning of the project in Feb 1999, involving all interested parties, to set the direction of the project

- A second meeting held at Windorah in October 1999 to review the project, and to seek opinions and guidance on where additional research and MLA involvement should be directed

- The formation of a project steering group comprising representatives from Stanbroke, AA Co, NAPCO, Kidman, private landholders, MLA and government agencies to oversee the project

- A flyer describing the Channel Country and the project was distributed to the general public throughout the Channel Country (Appendix 3)

- Group workshops and individual interviews with the managers of 25 properties (over 60% of the total number of Channel Country holdings) to acknowledge and record their valuable experiences and knowledge (in "Managing the Channel Country Sustainably. Producers' Experiences"), and to create lines of communication for the project

- The launch of "Managing the Channel Country Sustainably. Producers' Experiences" by Vince Edmondston by the Queensland Minister for Primary Industries and Rural Communities at Birdsville in April 2001

- The distribution of "Managing the Channel Country Sustainably. Producers' Experiences" to all Channel Country land managers with floodplains

- The involvement of over 75% of Channel County land managers through direct contributions to the project (through the steering committee, interviews or maintaining sites on their properties)

- Articles and interviews in various outlets, including local papers and radio, to publicise the latest developments and raise awareness of the project (Appendix 3)

- The distribution of 125 copies (to date) of "With Reference to the Channel Country. Review of available information". (CD Rom and book package) by Andrew White

- The distribution of 10 issues of the "Sustainable Grazing in the Channel Country Floodplains" newsletter to 110 project stakeholders and interested parties (Appendix 3), including all Channel Country land managers with floodplains

- On-going networking and consultation with scientific peers and other stakeholders

- The publication of results, and networking with other scientists, at conferences (including the International Rangeland Congress at Townsville in 1999 and the Australian Rangeland Society conference at Broken Hill in 2000)

- The demonstration of field techniques to approximately 50 project stakeholders during site visits and Landcare days

- Regular attendance of Catchment Committees, Landcare groups, Soil Board meetings and Regional Vegetation Planning Meetings to disseminate information

On-going consultation with the Georgina/Diamantina Catchment Committee, Cooper Creek Catchment Committee, Channel Country Landcare Group, Queensland Parks and Wildlife Service, Marree Soil Board, Western Queensland Beef Research Committee, South Australian Department of Environment, Heritage and Aboriginal Affairs, Private Consultants (e.g. Frank Badman), Griffith University, University of New England, University of Queensland and Griffith University.

This objective is linked to the MLA project objectives "Collect and document the existing scientific and experiential knowledge of the ecology and grazing management practices of the Channel Country", "Extend best practice to industry" and "Enhance communication between and within industry, the public and the scientific community" and was listed as objective 2 in the second phase of the project.

Objective 6. Compile and publish the literature review and the community consultation data

This objective was better defined within the second NHT phase of the project as:

1. Compile and publish the community consultation data as “Managing the Channel Country Sustainably-Producer’s Experiences”

2. Compile and publish the literature review

This objective has been fully met through the publication of:

- “Managing the Channel Country Sustainably. Producers’ Experiences” by Vince Edmondston is soon to be in its second reprint. Total of 250 copies printed to date.

- “With Reference to the Channel Country. Review of available information”. (CD Rom and book package) by Andrew White is soon to be reprinted. Total of 125 copies to date.

“Managing the Channel Country Sustainably. Producers’ Experiences” was distributed to every landholder within the Channel Country project area. A total of 250 copies have been printed to date, and a third re-print is underway.

“With Reference to the Channel Country. Review of available information” was initially distributed to 60 graziers, scientists, local mayors, co-operators and agency staff and is now in its second re-print.

Both publications were distributed to the Georgina/Diamantina Water Resource Plan Community Reference Panel to assist in their planning of the future allocation and use of water within the Georgina and Diamantina catchments. Copies have also been provided to the Lake Eyre Basin Coordinating Group, including to the Federal secretariat, to the Honourable Dr David Kemp (Federal Minister for the Environment and Heritage), John Hill (South Australian Minister for Environment and Conservation) and Dr Peter Toyne (Northern Territory Minister for Central Australia) and to leading scientists.

Station managers, scientists and policy makers have all found these publications useful, particularly as benchmarks documenting current practice and the current level of knowledge within the Channel Country.

This objective was linked to the MLA project objectives: “Extend best practice to industry” and “Enhance communication between and within industry, the public and the scientific community” and was listed as Objective 7 in the second NHT phase of the project.

Objective 7. Produce and publish “Managing Grazing in the Channel Country”

“Managing Grazing in the Channel Country” has not been published. The success in defining and identifying the range of sustainable management practices and best practice grazing systems has been limited by the failure to meet Objectives 2 and 3 in their entirety (due to the dry conditions, as discussed within Objective 2). Whilst a good set of baseline data has been compiled (see Results and Discussion section), there is insufficient information available to compile a guide to sustainable grazing. As discussed in Objective 2, more flood events require monitoring to determine potential grazing impacts, and to allow the successful modelling of pasture production.

The allocation of only half of the requested funds from NHT made it difficult to meet many of the initial project objectives. Through consultation with the community, it was decided to proceed with Objectives 1 and 6 in lieu of Objectives 7 and 8. The publication of the grazier’s guide was contingent upon MLA Objectives 2 to 4 (“Develop and enhance the limited scientific knowledge of the ecology and response of the Channel Country vegetation and soils to flooding events”, “Develop and enhance the limited technical knowledge of the effects of current grazing practices" and "Identify, refine and produce tools for use in decision making for managing grazing of the natural pastures"), which have been achieved to varying degrees due to the high variability of the system and the long term nature of the monitoring required.

The steering committee has expressed concerns over attempting to provide on ground management guidelines and advice from short-term results within the high variably of the Channel Country. Their recommendation has been that there is currently insufficient data to produce effective decision-making tools, and that the graziers guide should not proceed until there is sufficient information. They have expressed concerns over the risks involved of getting the message wrong, with the potential to damage natural resources rather than enhance having strong implications for future generations of managers.

This objective was linked to the MLA project objective "Extend best practice to industry" and was listed as Objective 1 in the second phase of the project. MLA has approved the deferment of milestones associated with publishing the grazier's guide.

Objective 8. Produce and publish "Plants of the Channel Country" in association with the Channel Landcare Group

"Plants of the Channel Country" has not yet been completed. Assistance through "Sustainable Grazing in the Channel Country Floodplains" was halted because of the reduction in NHT funding described under Objective 7. Work on the publication "Plants of the Channel Country" is continuing, although the retirement of the main author has led to some delays in its completion. A late 2003 release is anticipated.

This objective was linked to the MLA project objective "Enhance communication between and within industry, the public and the scientific community" and was listed as Objective 9 in the second NHT phase of the project and refined to better reflect the community focus of the publication. The publishing of "Plants of the Channel Country" was removed from both NHT and MLA agreements as an objective.

IMPACT ON NATURAL RESOURCE MANAGEMENT - NOW AND IN FIVE YEARS TIME

The cattle industry in the Channel Country will benefit from ensuring cattle production is sustainable and productive, with information from the project forming the basis of best practice guidelines and codes of practice that are prerequisites to developing Environmental Management Systems (EMS), as well as for informed debate over the future role of grazing within these extensive areas. In addition, the knowledge gained should have application to other floodplains and naturally flooded country, including the Bulloo River of south west Queensland, flooded lake systems and bluebush swamps within South Australia and the Northern Territory.

Whilst industry can begin to see immediate benefits as they develop EMS programmes, it will take a further 3 to 5 years to see benefits through an improved capacity to budget for cattle production based on both available and predicted feed on offer. This will depend on improving the scientific capacity in, and accuracy of, computer software which models pasture growth in response to flood and rainfall events. The accuracy of these models can only be improved through further field data collection and monitoring of pasture growth responses.

The capacity to predict pasture yields from flood and rainfall events shows promise, but requires more work to become reliable as a cattle and feed budgeting tool. In particular, winter floods are yet to be documented, with only summer floods experienced to date through the course of the project. The importance of winter floods may be greater than summer floods, with the highly regarded Cooper clover only growing in the cooler months. Cattle growth rates of 2 kg/hd/day are often quoted on the lushest feed following floods.

It will also be another 3-5 years before industry will be able to scientifically demonstrate they are applying sustainable grazing practices through the grazed/ungrazed transects. Once this can be demonstrated, industry will have a basis to argue that biodiversity and the environment are promoted through responsible custodianship e.g. low impact activities are good for the algae, which is good for the fishes, which is good for the birds etc. Industry will only be able to infer however, not document, these effects under the current project monitoring system.

There is also scope to improve the ability to use remote sensing data to monitor flood events, grazing impacts and the subsequent broad-scale pasture response, and through ensuring the application of the information is valid across a broad region.

The project has the potential to deliver between $3 and $20 million worth of improved cattle production per annum, without sacrificing the environment or impacting on the natural resource base. An estimated 0.5 to 1 million head of cattle are run in the Channel Country of Queensland, with a recorded gross turn-off value of $64.6 million in the 1998-99 financial year. Turn-off following major flood events, such as in 2000, is reputedly in excess of $150M worth of beef.

Even small improvements in the efficiency of production, or increases in animal numbers, can have significant economic impacts. A 5% gain, for instance, would provide a further $3.2 million per annum (based on an annual turn off of $64.6 million). It is possible that gains in the order of 10 to 30% ($6.4 to 20 million) are possible under current management practices. Improvements in the ability to predict flood induced pasture growth, pasture quality and animal performance will provide individuals and companies with opportunities to respond more quickly to flood events, and make use of available feed without fear of damaging the natural resource base.

METHODS

Documenting current knowledge

Existing knowledge was documented through a series of group workshops and individual interviews with 39 property managers within the Channel Country. Focussed discussion was encouraged on topics relating to the ecology and management of the Channel Country. Interview notes were compiled, summarised and sent to each interviewee for checking and comment. A final draft of the publication “Managing the Channel Country Sustainably. Producer's Experiences” (Edmondston 2001) was sent for review to participants and to professional editors before being launched by the Queensland Minister for Primary Industries at Birdsville on 26 April 2001. This launch coincided with the signing of the Lake Eyre Basin Agreement and was well attended by graziers and other stakeholders.

A thorough literature review has been published (“With Reference to the Channel Country. Review of available information”, White 2001). All available published and unpublished historical and scientific information, including documentary videos and paper based publications, were accessed for this review.

Both publications were funded by NHT project funds.

Expanding the knowledge base

Natural resource research and monitoring has been undertaken throughout the Cooper Creek, Diamantina River and Georgina River of the Lake Eyre Basin catchment since 1999. Seventeen monitoring sites (Table 3) were strategically located to span three major floodplain systems, three Land Systems and to capture potential variation from the north to the south of the catchment (e.g. flood size, frequency or duration). The resulting site distribution (Table 1) has provided a relatively even frequency of sites within each river system, and allowed for the summarising of data across river systems and Land Systems. Site-specific measurements have been conducted to capture changes in soil moisture, pasture yield and pasture quality subsequent to rainfall and flood events, and to benchmark potential grazing impacts.

Rainfall and flood patterns

Rainfall has been monitored via accumulating rain gauges at each site, supplemented by property records and interpolated daily rainfall data (Jeffrey *et al*. 2001). Broad rainfall trends and subsequent flood events have been sourced through available public records. Flood height, timing, duration and likely impacts have been sourced from property records supplemented by water depth sensors for eight key sites (Table 3) to enable continuous monitoring of flood height and duration.

Soil relationships

Samples to allow soil chemical analysis were extracted in 10 cm increments to 100 cm depth, during the initial monitoring of each site during 1999 and 2000. The analyses conducted were: pH and electrical conductivity (mS/cm) (1:5 soil: water), total nitrogen (%), available phosphorus (bicarbonate extractable, mg/kg), organic carbon (Walkley and Black method, %), chloride (mg/kg) and particle size (sand, silt, clay proportions) (Bruce and Rayment, 1982). Samples at strategic depths were chosen for analysis.

Soil moisture to 100 cm depth (in 10 cm increments) has been monitored from 1999 through to 2002 by auguring three soil holes (within the exclosure and near, but not within, pasture sampling quadrats) at the same dates as pasture yield harvests, supplemented by additional sampling between pasture harvests.

Soil moisture is presented as gravimetric data, in the absence of bulk density measurements. However, for the purposes of pasture growth modelling, bulk densities of 1.1 g/cm^3 (0-10 cm), 1.2 g/cm^3 (10-40 cm) and 1.3 g/cm^3 (40-100 cm) have been assumed to allow the calculation of volumetric soil moisture. These bulk density values are consistent with similar soils (e.g. Clewett 1985, Phelps and Gregg 1991) and assume linearly increasing values consistent with the alluvial soils of the Flinders River (Clewett 1985).

Table 3. Site location in relation to Land System, sub-category (bluebush or lignum dominant), river and catchment position.

Site number	Latitude[1]	Longitude[1]	Land System	Sub-category	River	Catchment position
1	24:49:44	139:38:20	C1	bluebush	Georgina	mid
2*	26:42:42	139:28:35	C1	bluebush	Diamantina	lower
3	24:55:06	140:28:11	C1	bluebush	Diamantina	mid
4*	26:46:04	141:59:36	C1	bluebush	Cooper	lower
5	25:38:58	142:12:39	C1	bluebush	Cooper	mid
6*	23:29:26	139:49:09	C1	lignum	Georgina	upper
7	24:53:12	139:38:36	C1	lignum	Georgina	mid
8	24:50:39	140:35:13	C1	lignum	Diamantina	mid
9	27:03:56	138:31:55	C1	lignum	Diamantina	lower
10*	25:41:04	142:10:25	C1	lignum	Cooper	mid
11*	23:51:30	139:53:39	C2	Open plains	Georgina	upper
12	25:12:53	140:43:56	C2	Open plains	Diamantina	mid
13*	23:31:01	141:22:04	C2	Open plains	Diamantina	upper
14	25:52:09	141:56:55	C2	Open plains	Cooper	mid
15	23:43:52	139:41:48	C3	Outer channels	Georgina	upper
16*	25:36:36	140:19:49	C3	Outer channels	Diamantina	mid
17*	25:49:48	142:01:06	C3	Outer channels	Cooper	mid

*site is fitted with an automated flood meter

[1]degrees:minutes:seconds, datum is GDA94

Pasture relationships

The three major floodplain Land Systems of Cooper (C1), Cunnawilla (C2) and Woonabootra (C3) (Table 1, Figure 5) were chosen for study of pasture relationships and subsequent pasture modelling. Kendall (C1 within Part V or WARLUS, to the north of Windorah) was excluded based on its relatively small area, and the regionally held belief that Kendall does not represent “true” Channel Country. However, extrapolation from Cooper to Kendall may be possible.

Each site comprised a 1 to 2 ha exclosure to exclude cattle grazing and ensure measured pasture yields represent maximum growth. Exclosed sites were paired with an un-fenced area to allow comparisons with normal grazing. Measurements within each area were designed to quantify vegetation responses to flood and rainfall events based on the SWIFTSYND pasture sampling procedure (Day and Philp 1997) as input to the GRASP pasture model (McKeon *et al*. 1990). The data has been used in preliminary modelling of rainfall and floods, which will provide a tool for predicting pasture production and form the basis of improved grazing management.

The measurements conducted at each site subsequent to flood and rainfall events have been:

- The yield of the five plant groups (bluebush, forbs, annual grasses, perennial grasses and other plants) comprising the pasture. Samples are harvested manually with hand shears from nine 1m^2 quadrats, and on 4 to 6 occasions following flood or rainfall events

- The height of the pasture from the same quadrats and at the same harvest dates

- ground cover (separated into green, dry, bare, rock, litter) from the same quadrats and at the same harvest dates

- site and quadrat photographs at the same harvest dates, supplemented with additional dates

- nutrient and dry matter levels of the plant groups (sub-sampled as groups rather than species or components) through the analysis of harvested material. Ground plant group samples of a minimum 50g ground weight were duplicated to allow comparative analysis using both standard laboratory chemical and NIRS approaches (Table 4)

Site photographs were used to estimate yield at non-sampled dates, to estimate the yield of bluebush available as browse, to estimate the phase of growth (where 1=young fresh growth, 2=active growth, approaching flowering, 3=flowering/seed production and 4=senescence) of the dominant pasture component and to rank the quality according to potential cattle growth rates (where 1=good quality pasture, gaining >0.5kg/hd/day, 2=reasonable quality pasture, gaining 0.1 to 0.5kg/hd/day, 3= moderate quality pasture, maintaining –0.1 to 0.1 kg/hd/day, 4=poor quality pasture, losing between 0.1 and 0.5kg/hd/day, and 5=extremely poor quality pasture, losing >0.5kg/hd/day). The quality rank was based on the visual estimation of a number of factors which impact on the ability of the animal to maintain liveweight, including greenness and apparent feed quality (including the probability of meeting crude protein and digestibility requirements), apparent moisture levels and the potential ability to achieve adequate intake levels (based primarily on accessible green yield).

Given the variable nature of rainfall and flood events throughout the large monitoring area, an initial sampling schedule based on individual sites was chosen. Initial recordings were conducted as sites were exclosed, and subsequent sampling according to property manager's advice on rainfall and flooding. Whilst potentially efficient, this approach has been problematic for data management. All accessible sites have been recorded in a single trip, or within a reasonable time frame, from May 2001 onwards. Site photographs, soil moistures or pasture samples have been collected as appropriate.

Table 4. Pasture chemical and NIRS analyses and procedures

Parameter	Technique	Reference
Dry matter (DM)	weight change following oven heating at 105°C for 24h	Faichney and White (1983)
Inorganic ash	ignition in a muffle furnace at 600°C for 3h	Faichney and White (1983)
Phosphorus (P)	colorimetric method following ignition at 600°C for 3h and HCl digestion	A.O.A.C. (1980)
Total nitrogen (N)	combustion method using an ELEMENTAR RapidN analyser	Sweeny (1989)
Crude Protein (CP)	Calculated from total nitrogen using the formula % CP= 6.25* %N	
Acid Detergent Fibre (ADF) and Neutral Detergent Fibre (NDF)	analysed using the FIBRETEC 2021 FIBRECAP system according to EEC standard	
Invitro Dry Matter Digestibility (IVDMD)	the two stage (rumen fluid) technique of Tilley and Terry (1963) as modified by Minson and McLeod (1972)	Minson and McLeod (1972)
Metabolisable Energy (ME)	predicted from IVDMD using Equation 58 (ME = 0.15 times DOMD%, where DOMD% = (OMD%(100 - Ash%))/100) and OMD% is % Digestibility of the organic matter (Equation 55)	Technical Bulletin 33 (1975)
NIRS nitrogen	Predicted from spectral analysis of supplied samples, using standard CSIRO calibration equation	David Coates (*pers comm*. 2002)
NIRS IVDMD	Predicted from spectral analysis of supplied samples, using standard CSIRO calibration equation based on the pepsin cellulase technique	David Coates (*pers comm*. 2002)

Vegetation changes under grazing

Comparisons of species growing inside and immediately outside the exclosures were made at all fenced sites in July 2002. Species presence and total yield was recorded in 30 permanently marked quadrats, each 1 m^2, along a transect in the grazed and exclosed areas of each site using the BOTANAL visual estimation method of Tothill *et al*. (1992).

Bluebush yields in August 2002 were estimated based on stem numbers. A regression equation linking bluebush stem numbers (in categories) and stem weights was derived in the field. Entire bluebush plants with 0-10, 11-20, 21-30, 31-40, 41-50 and >50 stems were cut and weighed. Where available, three plants within each category were cut and weighed. The weight of bluebush plants rooted in each quadrat were then estimated based on the number of stems per plant, a significant ($P<0.001$, $R^2=79.2$, $n=14$) relationship between stem number and weight (Figure 6) and the equation derived from this regression relationship (Equation 1).

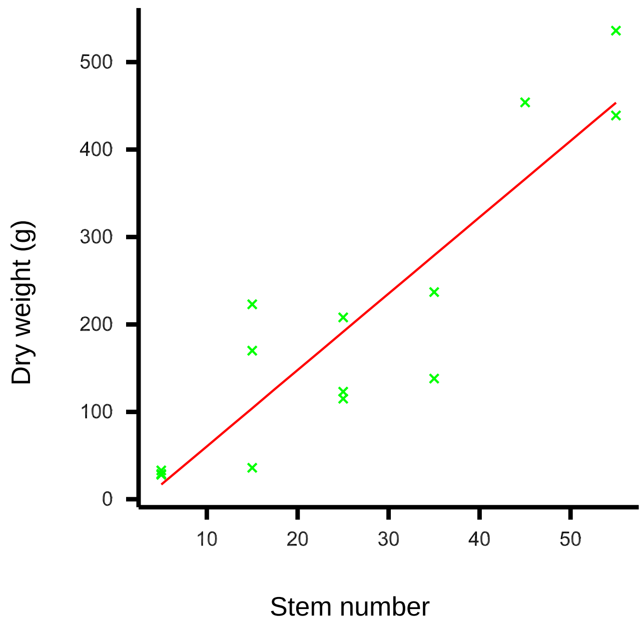


Figure 6. The relationship between bluebush stem number and dry weight (g/quadrat).

Equation 1. Predicted bluebush yield, based on stem numbers

Bluebush yield = (8.74*stem number -26.9)*10

Where 8.74 is the slope of the linear regression line, -26.9 is the intercept and 10 is the factor to scale yield from g/quadrat to kg/ha.

Preliminary modelling to integrate data and predict pasture growth

Initial relationships between soil moisture and pasture parameters were explored within the statistical package GenStat (GenStat 2000).

Preliminary modelling was conducted for a C1 (bluebush) site by Ken Day, Grant Fraser and Brigid McCallum, with advice from David Phelps, using the GRASP and WinGRASP pasture modelling packages, based on collected pasture, soil and rainfall data and supplemented with interpolated daily rainfall and climate (e.g. air temperature and humidity) data from the Bureau of Meteorology (McKeon *et al*. 1998, Jeffrey *et al*. 2001). Time did not permit evaluation of data from all sites.

The C1 (bluebush) site on the Diamantina was chosen for the preliminary study as it was likely to expose difficulties in modelling data from the range of sites. At the time of modelling, rainfall and flood records were only available for the first two years and flood records were based on a stream gauging station only, representing the minimum data set that is likely to be obtained from all sites. The presence of a combination of bluebush and annual grasses as well as frequent flooding makes this site a challenge for modelling. Data for the last year of the study is currently incomplete but an attempt was made to model this period. For the last year, the data is probably representative of the minimum information that may be currently at hand for modelling.

Modelling aims

The aims of the preliminary modelling were to:

- indicate the feasibility of calibrating GRASP to available data,
- make an initial evaluation of the strengths and weaknesses in the Swiftsynd data as currently at hand,
- indicate the more critical nature of some data and
- indicate further requirements in terms of completing data collection and analysis.

An accurate simulation of the SWIFTSYND observations was not an aim of the current exercise.

Modelling approach

Simulations were conducted using the same model parameters for the entire study period. It is likely that changes to parameters may be necessary to simulate biomass given the high ‘annual’ pasture component in 2001/2. However insufficient rainfall/flooding data was available to calibrate the model specifically for this period. Insufficient time was available to get all pasture records in a format for modelling during this period.

Communication methods

Strategies to enhance communication between and within industry, the public and the scientific community have included:

- A planning meeting held at the beginning of the project in February 1999, involving all interested parties, to set the direction of the project
- A second meeting held at Windorah in October 1999 to review the project, and to seek opinions and guidance on where additional research and MLA involvement should be directed

- The formation of a project steering group to oversee the project, which has now met 7 times
- A flyer produced (updated in 2002) and distributed to the general public and scientific community with facts and figures on the Channel Country and details of the project
- On-going production of 10 project newsletters informing stakeholders of the latest developments
- Group workshops and individual interviews with property managers to acknowledge and record their valuable experiences and knowledge, and to create lines of communication for the project
- Regular attendance of Catchment Committees, Landcare groups, Soil Board meetings, Georgina-Diamantina water resource plan Community Reference Panel and Regional Vegetation Planning Meetings to disseminate information and engage in natural resource management discussions
- Articles and interviews in various outlets, including local papers and radio, to publicise the latest developments and raise awareness of the project
- On-going networking and consultation with scientific peers and other stakeholders

RESULTS AND DISCUSSION

Rainfall and flood patterns

Cooper Creek recorded the highest frequency and magnitude of flood events between January 1999 and August 2002, with five major and four moderate floods spread over approximately 10 weeks total duration (Table 5, see Appendix 2 for definitions of flood heights and historical records). All of these floods occurred over the summer pasture growing period of November to March. Each summer period (1998-99, 1999-2000, 2000-01 and 2001-02) received flooding, with the largest event occurring over the 1999-2000 summer.

These floods were generally coupled with well above average to extreme rainfall events. Winter periods have generally received below average rainfall, insufficient to promote floods in the cooler months. The lack of winter floods may be significant, as cool season floods generally promote the growth of the highly valued Cooper clover (Edmondston 2001).

The Diamantina recorded one major, four moderate and one minor flood event spread over the same summer period as the Cooper. The Georgina recorded three moderate and three minor flood events over the same period. It is difficult to estimate the duration of flooding for the Diamantina and Georgina Rivers based on the readily available Bureau of Meteorology (BOM) reports. More detailed information is being sought.

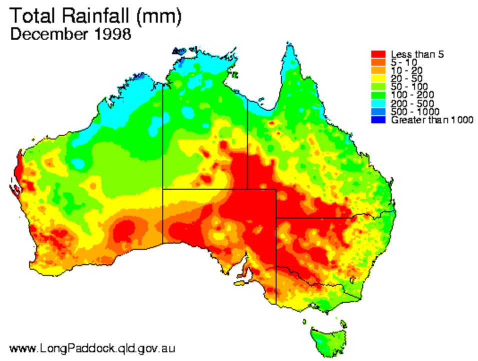
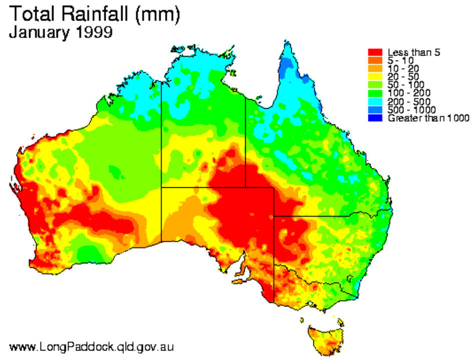
The Cooper Creek catchment drains approximately 296,000 square kilometres, including areas of the Great Dividing Range to the north of Longreach and the east of Blackall and Tambo. The Georgina River (including Eyre Creek) drains approximately 242,000 square kilometres, predominantly in the arid areas of western Queensland and the eastern Northern Territory, but including a small area of potentially high rainfall to the north west of Mt Isa. The Diamantina River catchment drains approximately 158,000 square kilometres, including areas of relatively high rainfall within the Kynuna district of north-western Queensland and high run-off areas within the Mulga country of south western Queensland (White 2001).

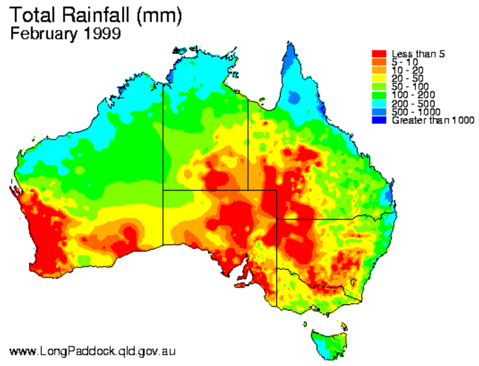
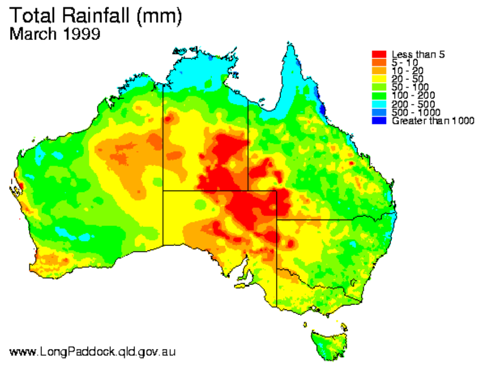
The interval between floods was greater in the Diamantina and Georgina than the Cooper. For instance, the Cooper experienced major flooding in January 1999, followed by moderate flooding in March 1999, November 1999, December 1999 and major flooding in January 2000. The Diamantina and Georgina generally experienced only moderate flooding during January 1999 and January 2000, a full 12 month inter-flood duration compared with a flood every quarter (on average) for the Cooper.

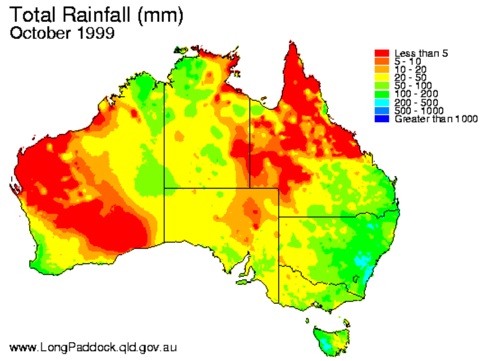
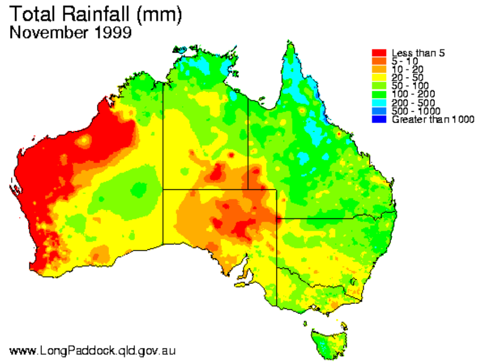
Both the magnitude of the floods experienced, and the frequency of their occurrence may reflect the increasing aridity of the catchments of each system from east to west. It may also reflect the size and run-off potential (in terms of soil types and terrain roughness) of each catchment.

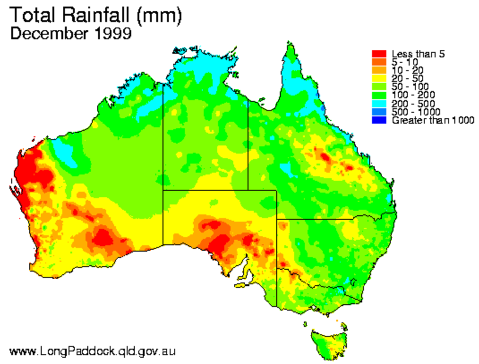
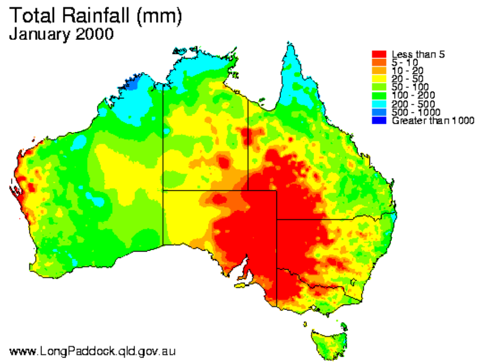
Widespread major flooding through any of the river systems is dependent on rainfall events in excess of approximately 100 mm over a 24-hour period, and over a substantial proportion of the catchment. This is dependant on the level of soil moisture saturation and the amount of water already present in waterholes and river channels. The level of saturation is dependent on the immediate rainfall history and of the catchment (Bureau of Meteorology 2002a, 2002b). When soils are already moist from previous rainfall events, lesser falls of 75 mm may produce major flooding. Minor floods may occur over widespread areas, or moderate to major floods over isolated areas, from widespread falls of 50 to 75 mm. The likelihood of widespread falls in excess of 50 mm declines from east to west.

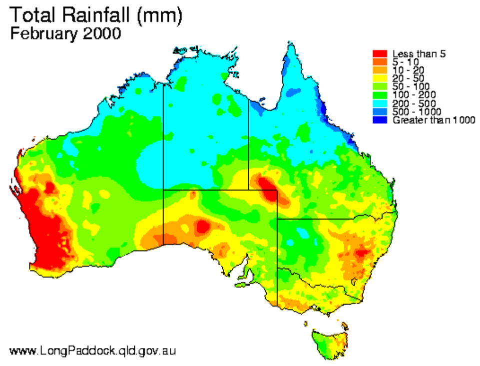
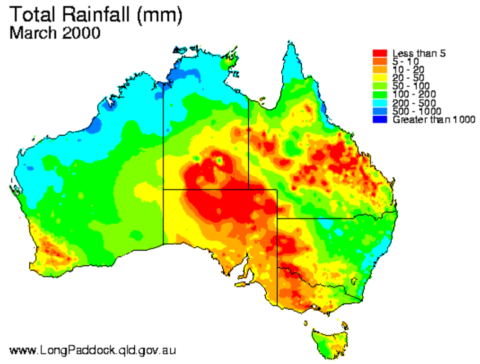
Table 5. Summary of official flood events and associated rainfall patterns for Cooper Creek, Diamantina and Georgina Rivers between January 1999 and August 2002 (Bureau of Meteorology 1997, 2000a, 2000b, 20002a, 2002b, <www.bom.gov.au/hydro/flood/>). Rainfall presented as Australian rainfall distribution relative to historical records (Long Paddock 2002, <www.longpaddock.qld.gov.au/>).

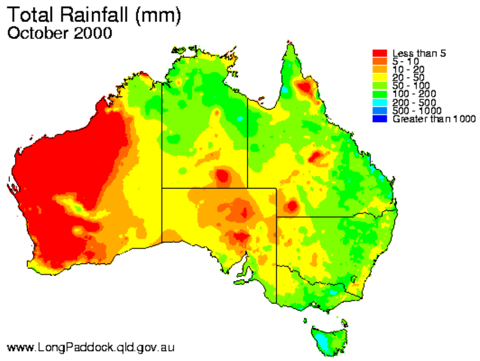
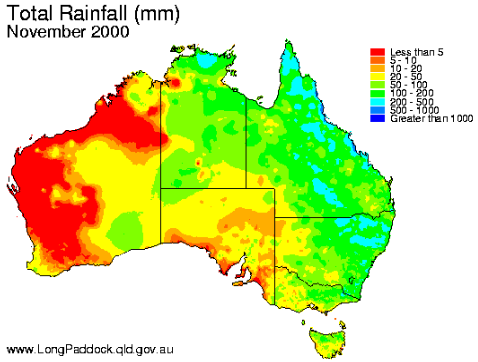
Date	Cooper Creek	Diamantina and Georgina Rivers	Associated rainfall pattern
January 1999	Rainfall in the upper reaches of the Thomson and Barcoo Rivers and in the lower reaches of the Thomson River between Longreach and Windorah resulted in river rises throughout the system and flooding by the 2nd. A major flood ensued at Windorah from the 7th for one week, falling to moderate flood levels by the 20th	Heavy rainfall in the upper reaches of the Diamantina River caused significant rises and flooding by the 2nd around Diamantina Lakes. River levels peaked at Diamantina Lakes on the 4th at 6.40 m, 1.4 m above the major flood level. Moderate to major flooding slowly developed downstream with the main flood waters peaking at 7.4 m at Birdsville on the 22nd with moderate flooding receding by the 27th Heavy rainfall in the Avon Downs (NT) to Mount Isa area resulted in river rises to minor flood level in the upper reaches of the Georgina River from Urandangie to Marion Downs on the 5th. Minor to moderate flooding continued in the Georgina River downstream to Glengyle on Eyre Creek for several weeks with a number of different peaks as the floodwaters travelled downstream. The main floodwaters were downstream of Glengyle by February 1st	 

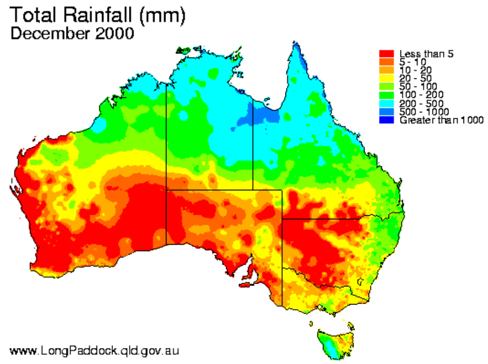
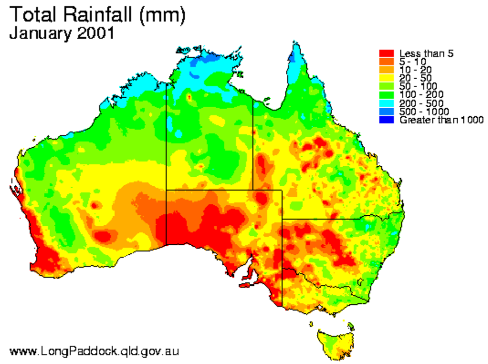
Date	Cooper Creek	Diamantina and Georgina Rivers	Associated rainfall pattern
February 1999	No flooding	No flooding	
March 1999	Rainfall at the beginning of the month caused rises in the lower Thomson River and Barcoo River with minor to moderate flooding. River levels in the downstream reaches of the Thomson and Barcoo Rivers peaked initially from local runoff, but renewed rises with continued minor to moderate flooding occurred as floodwaters from the upper catchments arrived. Moderate flooding developed at Windorah on the Cooper Creek on the 9th and high river levels were maintained for the following week as floodwaters travelled downstream	No flooding	

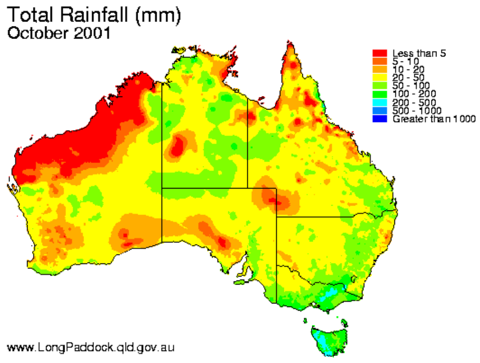
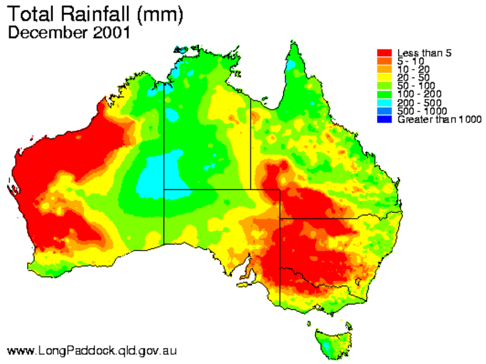
Date	Cooper Creek	Diamantina and Georgina Rivers	Associated rainfall pattern
April to October 1999	No flooding	No flooding	
November 1999	Rainfall over the weekend of the 20th, together with further scattered showers during the following week resulted in rises and moderate flooding in the Thomson River. Minor flooding occurred in the lower Barcoo River as a result of the initial rain, with renewed rises peaking as major flooding on the 30th at Retreat. By the end of the month river levels downstream at Windorah on Cooper Creek had reached the moderate flood level	No flooding	

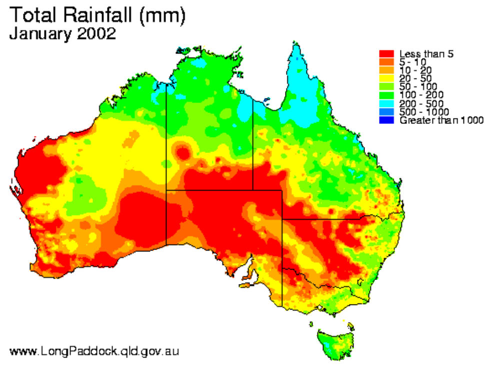
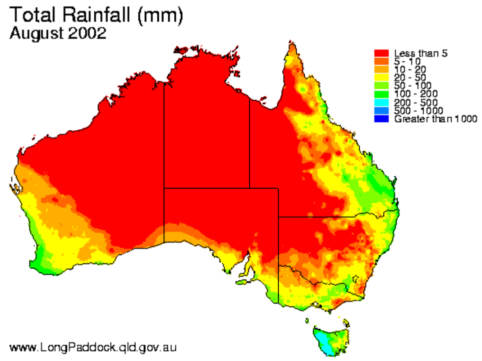
Date	Cooper Creek	Diamantina and Georgina Rivers	Associated rainfall pattern
December 1999	November waters reached major flood levels at Windorah by the 3rd, but were subsiding by the 6th. Renewed rises in the lower Thomson and Barcoo Rivers followed rainfalls of the 28th and again caused major flooding in the Windorah area which continued into the new year	No flooding	
January 2000	The main floodwaters in the Cooper Creek system were downstream of Windorah by the 1st. However major flooding was still occurring in Cooper Creek at Windorah and moderate flooding in the Thomson River at Jundah. Flood levels had subsided by the 5th	Minor to moderate flooding throughout the month, with a moderate flood peaking at Birdsville (Diamantina) on the 20th, and at Glengyle (Eyre Creek) on the 17th	

Date	Cooper Creek	Diamantina and Georgina Rivers	Associated rainfall pattern
February 2000	Very heavy rainfall over a few days in mid February resulted in major flooding in the Thomson River which continued downstream in Cooper Creek into March. The level of the Thomson River at Muttaburra was one of the highest flood peaks on record and this was reflected in the major flood levels reached at the downstream river height stations, including Longreach.	The township of Winton in the upper Diamantina River catchment was subjected to some of its most severe flooding on record mid month. The monsoonal trough that caused this rainfall resulted in widespread moderate to major flooding downstream along the Diamantina River that continued into March. Moderate to major flooding commenced in the upper reaches of the Georgina River mid month and continued in the lower reaches into March.	
March 2000	At the beginning of the month, major flooding was easing in the Thomson River at Longreach, with the main floodwaters downstream in the Jundah area. Major flooding continued into Cooper Creek during the month, with the floodwaters peaking at Windorah on the 3rd. River levels peaked at Durham Downs on the 17th and by the end of the month, the floodwaters were approaching Nappa Merrie. Flood waters in Cooper Creek were receding by the 19th	Moderate flooding on the Diamantina eased at Diamantina Lakes at the beginning of the month. A moderate flood at Monkira peaked over the 4th/5th and at Birdsville on the 23rd. Renewed rises occurred upstream during the middle of the month, but these did not have an impact on downstream levels Minor to moderate flooding occurred throughout the Georgina River and Eyre Creek system at the beginning of the month, with the main floodwaters still being in the upper reaches of the Georgina River in the Urandangie area. The floodwaters moved very slowly downstream during the month, peaking at Marion Downs on the 12th with major flooding, and Glengyle on the 22nd, with moderate flooding	

Date	Cooper Creek	Diamantina and Georgina Rivers	Associated rainfall pattern
April to October 2000	No flooding	No flooding	
November 2000	Moderate flooding occurred in the Thomson River from Muttaburra to Jundah from the 16th to the end of the month. On the Barcoo system, moderate to major flooding occurred mostly in the lower reaches of the Barcoo downstream of Blackall. The main flood waters arrived at Windorah on Cooper Creek by about the 26th and moderate to major flooding in the area continued into December	No flooding	

Date	Cooper Creek	Diamantina and Georgina Rivers	Associated rainfall pattern
December 2000	At the beginning of December, minor to moderate flooding was occurring in the lower Thomson River as a result of widespread rainfall in November. Minor flooding was easing in the lower Barcoo River and moderate flooding from earlier peaks was easing in Cooper Creek Widespread moderate to heavy rainfalls occurred in the upper Thomson and Barcoo River catchments on the 14th to 15th due to Tropical Cyclone Sam causing rises and minor to moderate flooding throughout both river systems These floodwaters reached Windorah by the 22nd, peaking as a major flood on the 27th	Moderate flooding was recorded at Elderslie and Diamantina Lakes mid month. High river levels receded relatively quickly at Elderslie but moderate flooding and high river levels were maintained at Diamantina Lakes from the 17th to the end of the month. The main floodwaters were approaching Monkira by the end of the month Continuous heavy rainfalls in the upper Georgina River catchment between about the 11th to the 29th caused moderate to major flooding throughout the Georgina River and Eyre Creek system. By the end of December, the main flood waters had peaked at Glengyle on Eyre Creek, with major flood levels easing very slowly upstream of Glengyle	
January 2001	December flooding continued well into January as a result of widespread rainfall in the upper Thomson and Barcoo River catchments through mid December and early January. A second, lower, peak reached Windorah on the 19th with the resulting minor flooding receding by the 23rd	Flooding continued in the Diamantina River as a result of rain in December and by the end of December the main floodwaters were approaching Monkira. Moderate flooding continued in the system until the 23rd By the end of December, the main flood waters had peaked at Glengyle on Eyre Creek, with major flood levels easing very slowly upstream of Glengyle. By the end of January moderate flooding in the lower reaches was easing	

Date	Cooper Creek	Diamantina and Georgina Rivers	Associated rainfall pattern
February to November 2001	No flooding	No flooding	
December 2001	On the 15th heavy falls of rain of up to 125 mm were recorded in the middle reaches of the Thomson and Barcoo Rivers. As a result, moderate flooding occurred in the lower reaches of the Thomson River and also in the lower reaches of the Barcoo River. A peak, just over the major flood level, was recorded at Windorah on the 26th	No flooding	

Date	Cooper Creek	Diamantina and Georgina Rivers	Associated rainfall pattern
January 2002	Heavy rainfall on the 5th, 6th and 7th caused minor flooding in the upper Barcoo and moderate flooding downstream. Heavy rainfall on the 5th and 6th caused minor flooding in the Thomson river between the 6th and 19th of the month. The flood waters from the Barcoo and Thomson combined to cause moderate flooding at Windorah, with a peak recorded on the 19th	Isolated occurrences of minor flooding in the Georgina River at Urandangie and in the Diamantina River at Diamantina Lakes during the middle of January	
February to August 2002	No flooding	No flooding	

Soil relationships

Soil chemical and physical properties

Full soil descriptions have not been conducted, but in general the soils are grey-clays (or Vertosols, Isbell 1996). The classification of Isbell (1996) requires a clay soil to have in excess of 35% clay at each depth. Particle size analysis from the 10-20 cm and 50-60 cm layers demonstrate that some individual sites have non-clay soils, with clay contents as low as 20 to 25% (data not presented). On average across river and Land Systems, however, clay levels are in excess of 50% (Figure 7).

Clay soils are generally alkaline (or basic) in their pH range. All Cooper Creek sites were strongly alkaline, with an increasing trend at depth (Figure 8). Diamantina and Georgina sites were neutral to alkaline, with variable trends. On the Diamantina, Site 12 displayed a strongly declining trend, with other sites exhibiting either a declining or consistent trend. Site 9 demonstrated a strongly increasing trend, despite having a lower clay content at 50-60 cm than at 10-20 cm depth. On the Georgina, Site 6 and Site 7 had an increasing trend, whilst Site 11 displayed a declining trend, becoming slightly acidic at depth. Site 1 demonstrated an increasing pH trend, in conjunction with an increasing clay content at depth.

Cooper Creek sites had low Electrical Conductivity levels, whilst some sites on the Diamantina and Georgina became saline (an EC of >4 mS/cm) at depth (Figure 9). Sites 2, 12 and 11 were saline at 50-60 and 90-100 cm depth, with Sites 16 and 7 saline at 90-100 cm depth only.

Chlorine levels were highest at depth at sites on the Diamantina, with Sites 12 and 16 reaching 8,000 and 10,000 mg/kg respectively (Figure 10). All other sites were similar in trend, with 90-100 cm depth tending to higher levels.

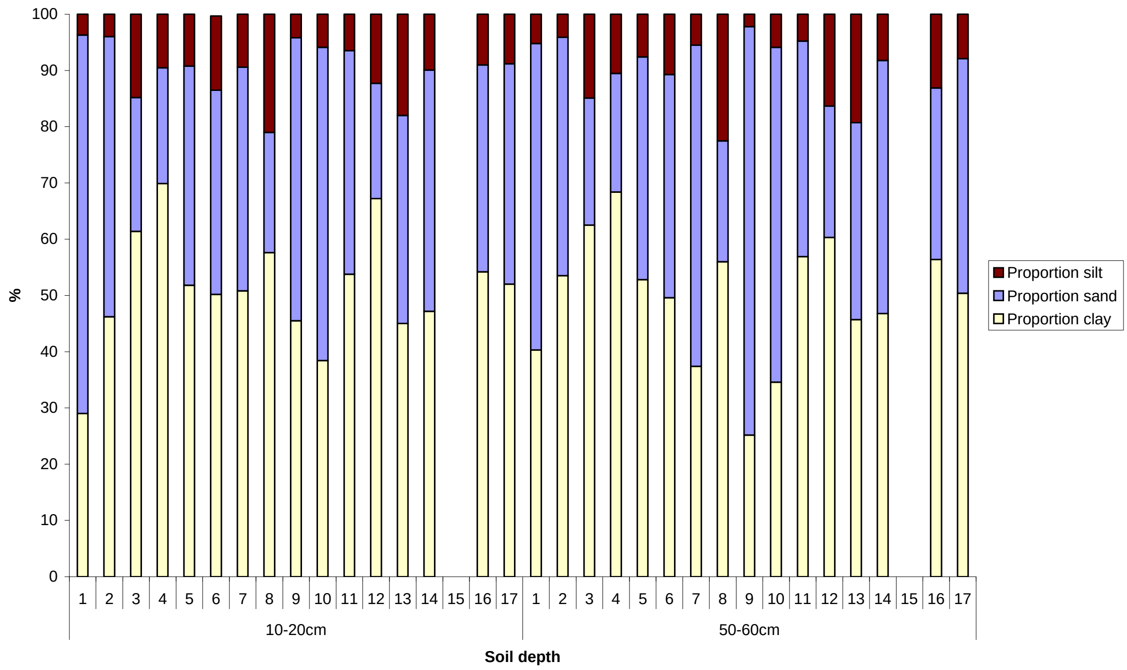
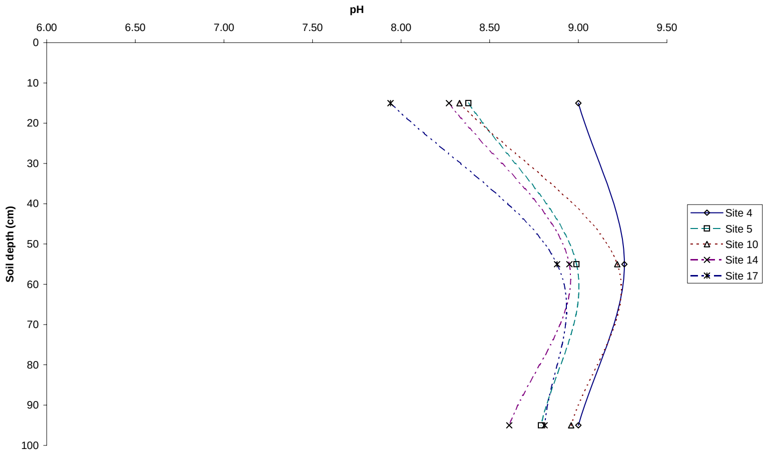
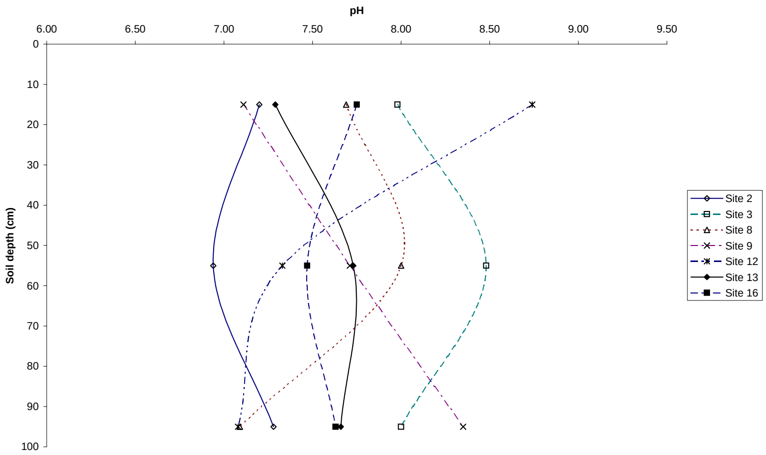


Figure 7. The proportions of sand, silt and clay at 10-20 and 50-60 cm depth at all sites.

a) Cooper Creek



b) Diamantina River



c) Georgina River

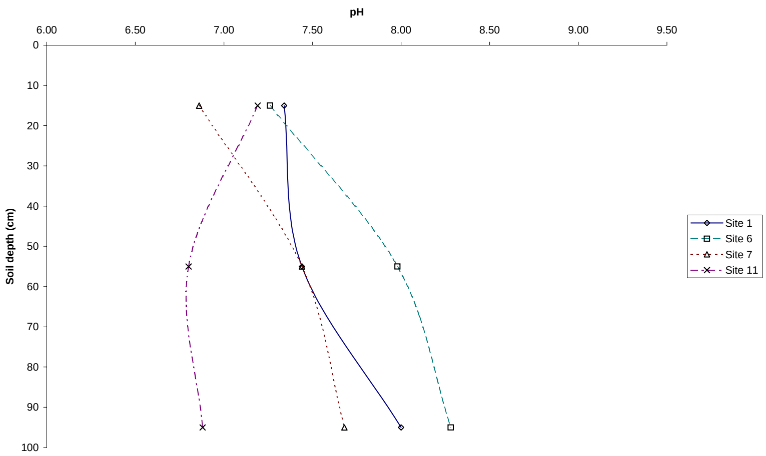
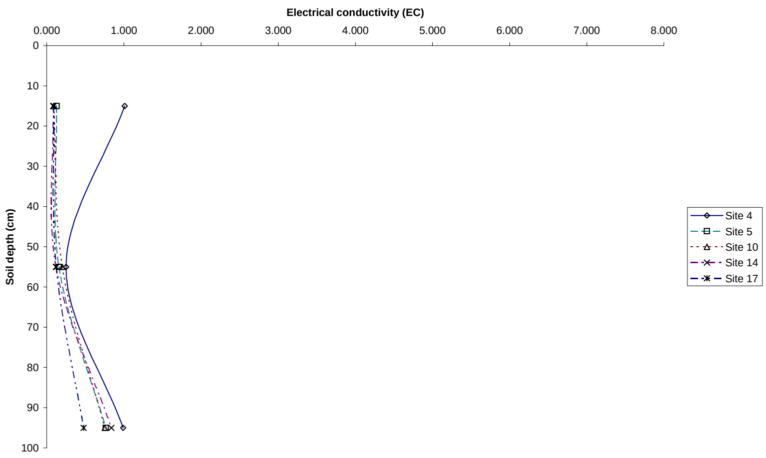
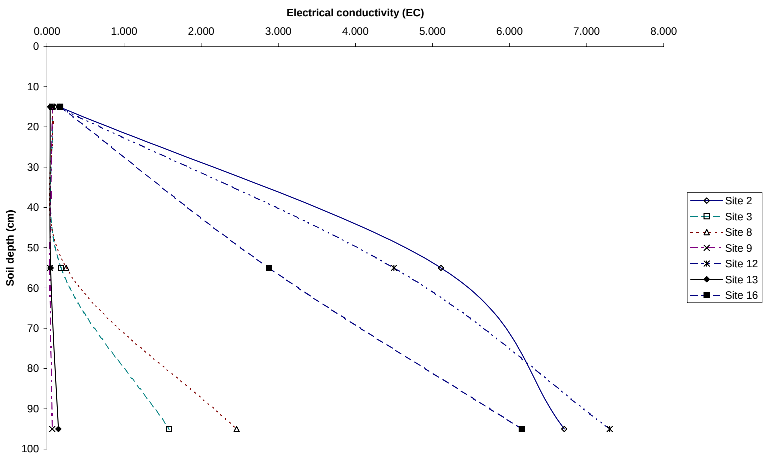


Figure 8. Soil pH at 0-10, 50-60 and 90-100 cm depth for a) Cooper Creek, b) Diamantina River and c) Georgina River sites.

a) Cooper Creek



b) Diamantina River



c) Georgina River

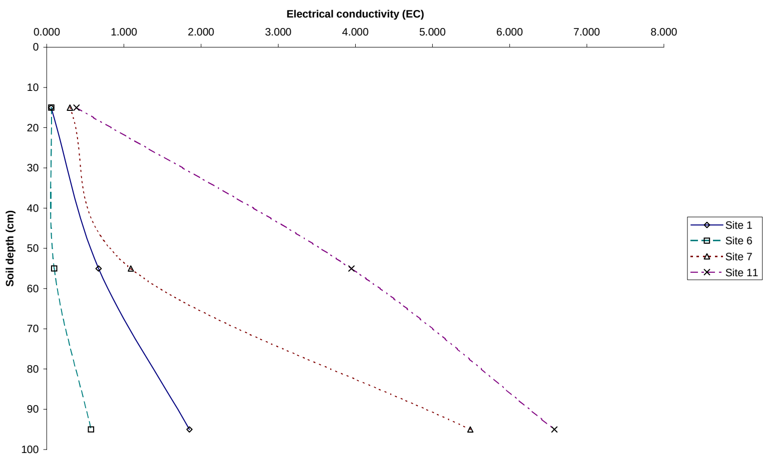
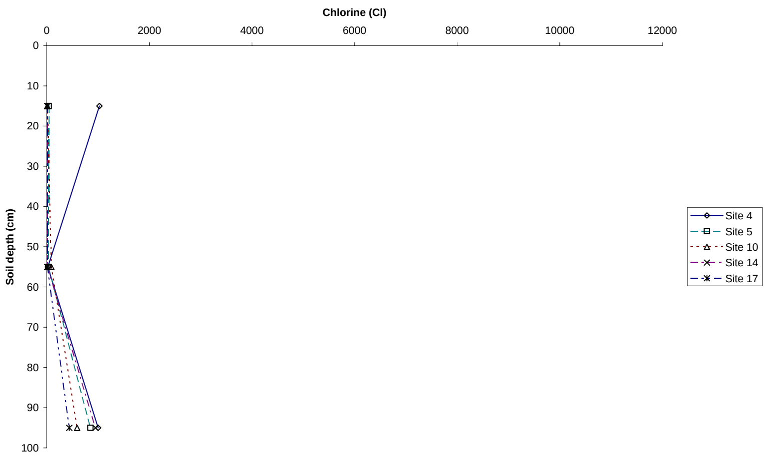
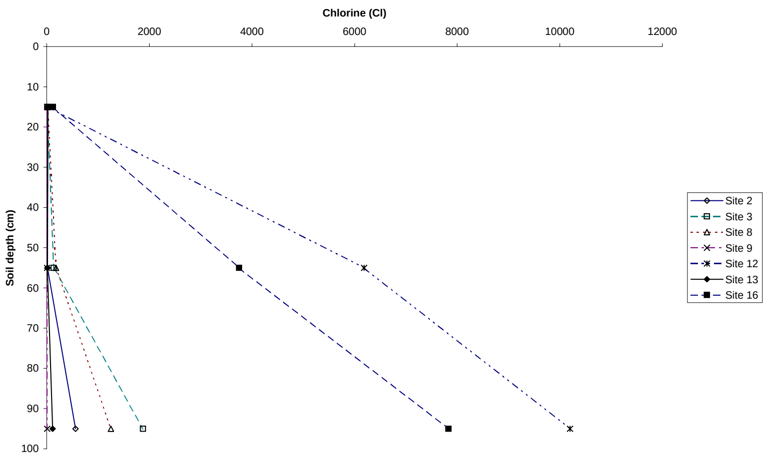


Figure 9. Soil Electrical Conductivity (EC, mS/cm) at 0-10, 50-60 and 90-100 cm depth for a) Cooper Creek, b) Diamantina River and c) Georgina River sites.

a) Cooper Creek



b) Diamantina River



c) Georgina River

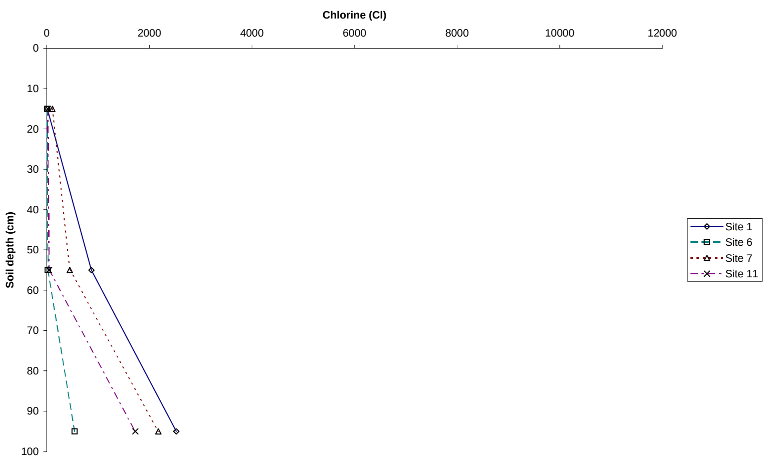


Figure 10. Soil Chloride levels (Cl, mg/kg) at 0-10, 50-60 and 90-100 cm depth for a) Cooper Creek, b) Diamantina River and c) Georgina River sites.

Available Phosphorus levels (Table 6) are high by Australian standards, which in general are low to very low. Grey clays have been noted to generally contain 27 mg/kg of P, placing the floodplain soils at the richer end of the scale for these soils (Russell and Greacen 1977). Soil Organic Carbon (organic matter, %) levels are low, even for Australian semi-arid soils which generally contain less than 6% OC (Russell and Greacen, 1977), but comparable to other soils within western Queensland (Mills and Ahern 1980). Total nitrogen (%) levels are also low, but comparable to other soils within western Queensland (Mills and Ahern 1980).

Table 6. Soil Phosphorus (mg/kg), organic carbon (%), total nitrogen (%) and plant available water (mm/m) at 10-20 cm depth for all sites.

Site no	Phosphorus (mg/kg)	Organic Carbon (%)	Total Nitrogen (%)	Plant Available Water (mm/m)
1	29.3	0.17	0.017	4
2	47	0.11	0.036	6
3	31.6	0.21	0.026	16
4	13	0.28	0.03	15
5	20.7	0.31	0.036	14
6	31.1	0.22	0.025	13
7	47.5	0.63	0.067	6
8	40	0.23	0.021	15
9	44.7	0.22	0.024	5
10	17.6	0.21	0.025	11
11	23.3	0.24	0.027	6
12	13.6	0.25	0.031	16
13	32.4	0.19	0.024	10
14	19.2	0.25	0.027	14
15	N/a			
16	32.7	0.25	0.026	10
17	24.9	0.33	0.035	16

Soil moisture

In general, water becomes unavailable to plants below soil moistures of 10%, although this varies with soil type. For clay soils, water generally becomes unavailable below 20% moisture content (Brady 1984). Soil moisture profiles for each site are presented in Figures 11 to 27.

The highest soil moisture values were recorded at Sites 4 (June 1999), 5 (June and July 2000), 8 (April 1999) and 10 (June 2000) at varying depths (Figures 14, 15, 18 and 20). Site 9 had the lowest soil moisture consistently over the monitoring period, not exceeding 15% moisture at any time or any depth (Figure 19). In general, Cooper Creek sites (Sites 4, 5, 10, 17; Table 3) had greater soil moisture levels than the Diamantina (Sites 2, 3,l 8, 9, 12, 13, 16) or Georgina (Sites 1, 6, 7, 11, 15), possibly reflecting a general increase in dry conditions (aridity) to the west of the study area, differing catchment areas or simply reflecting rainfall patterns during the study period. C1 bluebush (Sites 1 to 5) and C1 lignum sites (Sites 6 to 10) also tended to wetter soil moistures.

The highest values for wet soils (40-45%) compare favourably with other clay soils. Phelps and Gregg (1991) reported a peak moisture value of just under 40% following 180 mm simulated rainfall for a Mitchell grass clay soil. Clewett (1985) reported similar maximum values following irrigation of a grey clay on the Flinders River floodplain at Richmond.

Soils dried considerably following the 2000 flood event, with moisture levels declining steadily across all sites through to August 2002. Soil moistures generally dropped below the plant available moisture level of 20% at all sites by early 2001. Surface soils have generally dried to less than 10%, with some moisture retained at depth (below 50 cm soil depth).

Soil moisture trends down the profile suggest possible impediments to moisture penetration at depth, potentially through salt or gypsum layers, or possibly through soil texture changes. For instance, moisture at Sites 6 (Figure 16) and 13 (Figure 23) did not penetrate below the 60-70 cm layer, coinciding with an increase in soil pH at 50-60 cm depth (Figure 8). Site 3 (Figure 13) demonstrated a tendency to have low soil moistures at and below 70 to 80 cm depth, but maintained similar soil chemical properties at all recorded depths.

Low soil moistures at depth may reflect the rooting depth, and active moisture extraction, by bluebush or lignum, or simply reflect how dry the soil was prior to the flood or rainfall event.

Where the soil profile was wet, surface moisture levels had begun to dry at each recording date. This reflects difficulties in accessing sites when soils are between saturation and field capacity, particularly following large flood events. The main period of field capacity within the rooting zone of annual species may not have been captured to date, suggesting the need for alternative access methods (e.g. helicopter or boat access) or for alternative monitoring methods (e.g. automated and continuos soil moisture monitoring probes). Another alternative may be simulated wetting fronts under controlled conditions.

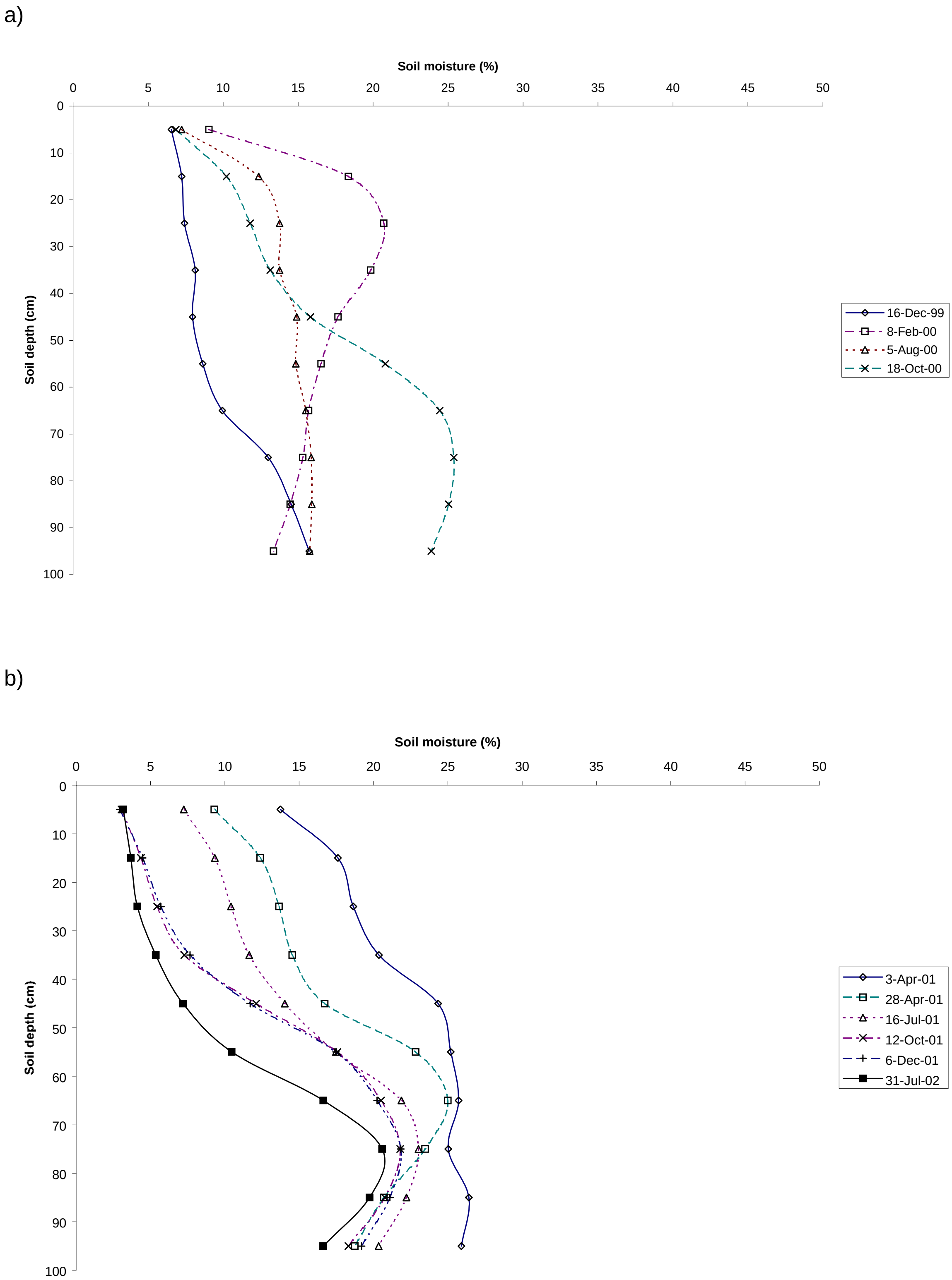
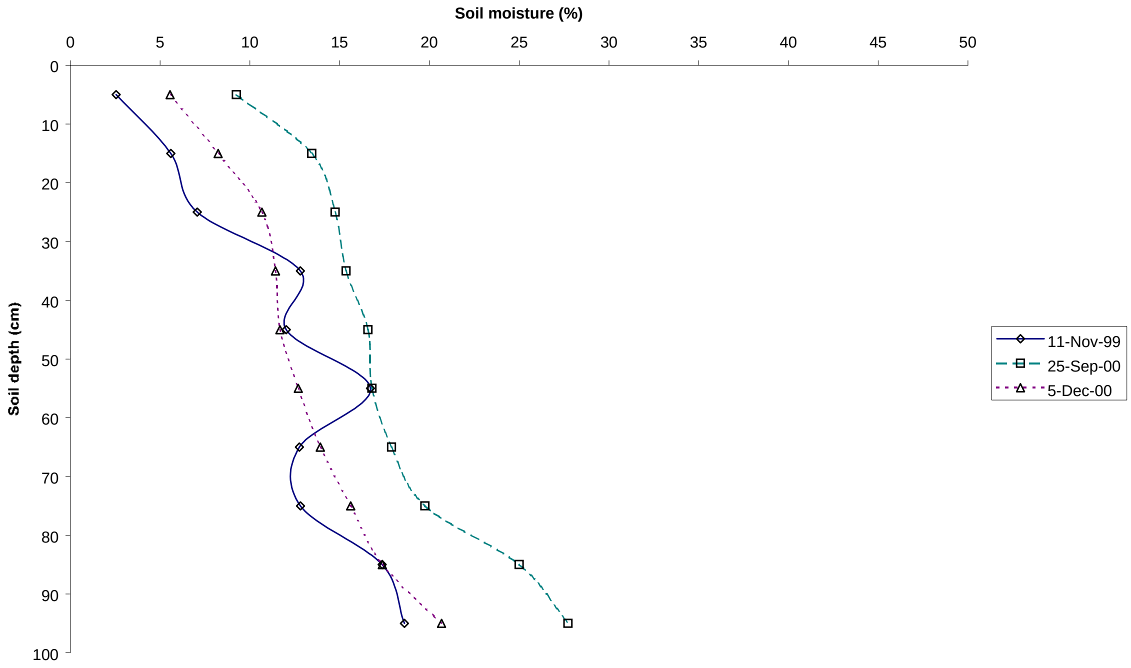


Figure 11. Site 1 soil moisture levels at a) December 1999 (◇), February (☐), August (△), October 2000 (✕), and b) April (◇,☐), July (△), October (✕), December 2001 (+), July 2002 (■).

a)



b)

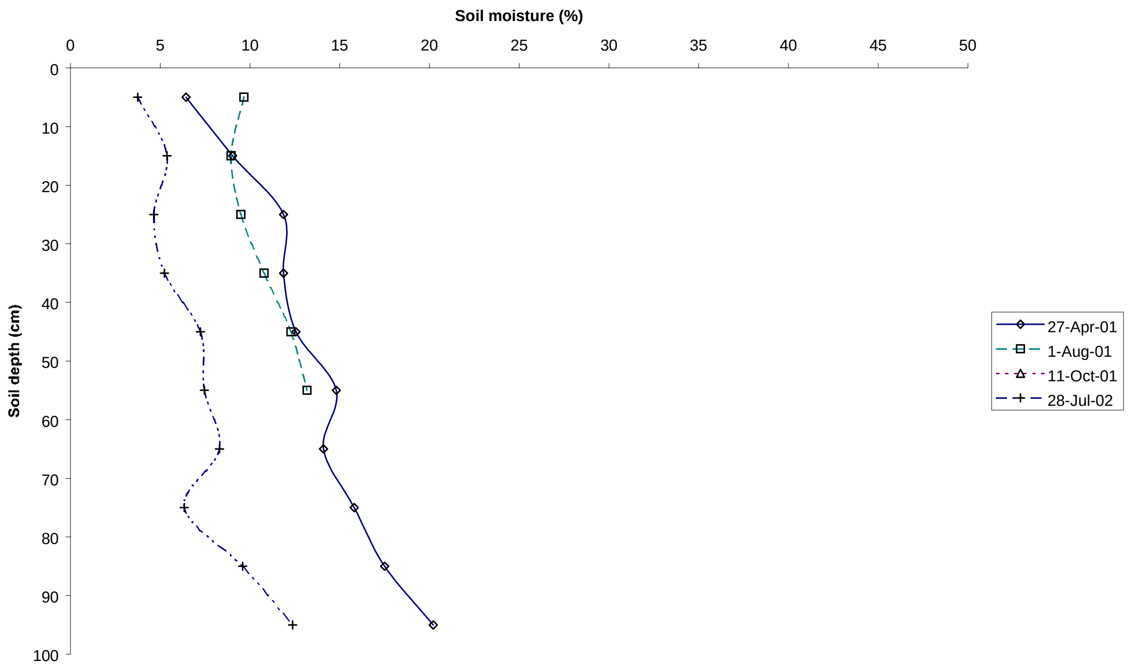
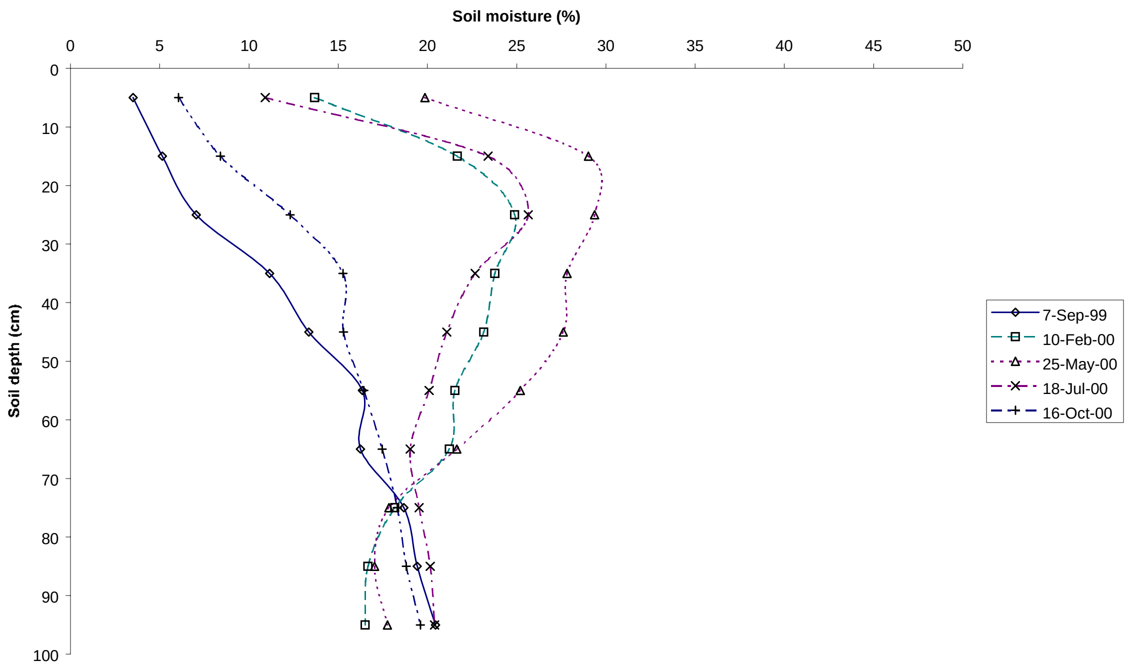


Figure 12. Site 2 soil moisture levels at a) November 1999 (◇), September (☐),December 2000 (△) and b) April (◇), August (☐), October 2001 (△), July 2002 (+).

a)



b)

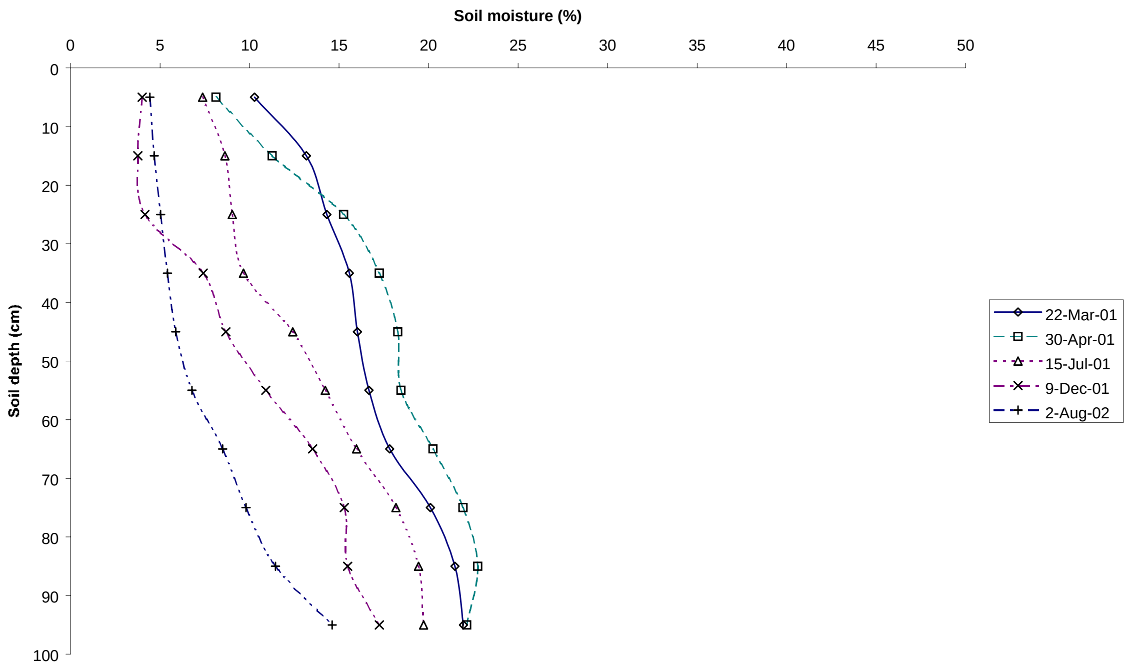
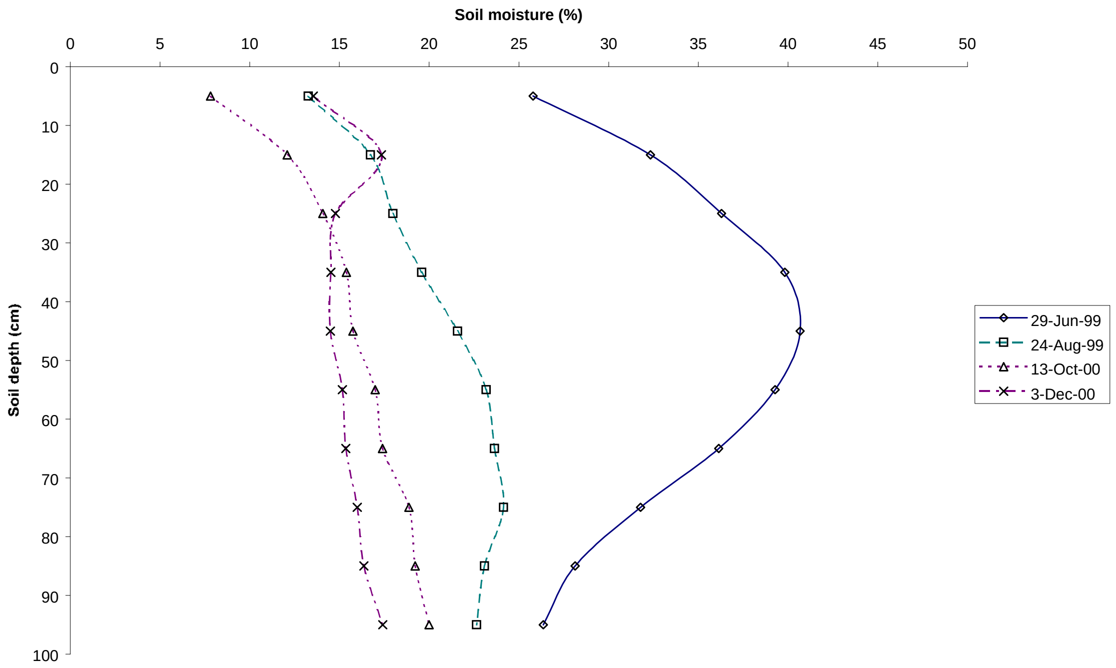


Figure 13. Site 3 soil moisture levels at a) September 1999 (◇), February (□), May (△), July (✕), October 2000 (+) and b) March (◇), April (□), July (△), December 2001 (✕), August 2002 (+).

a)



b)

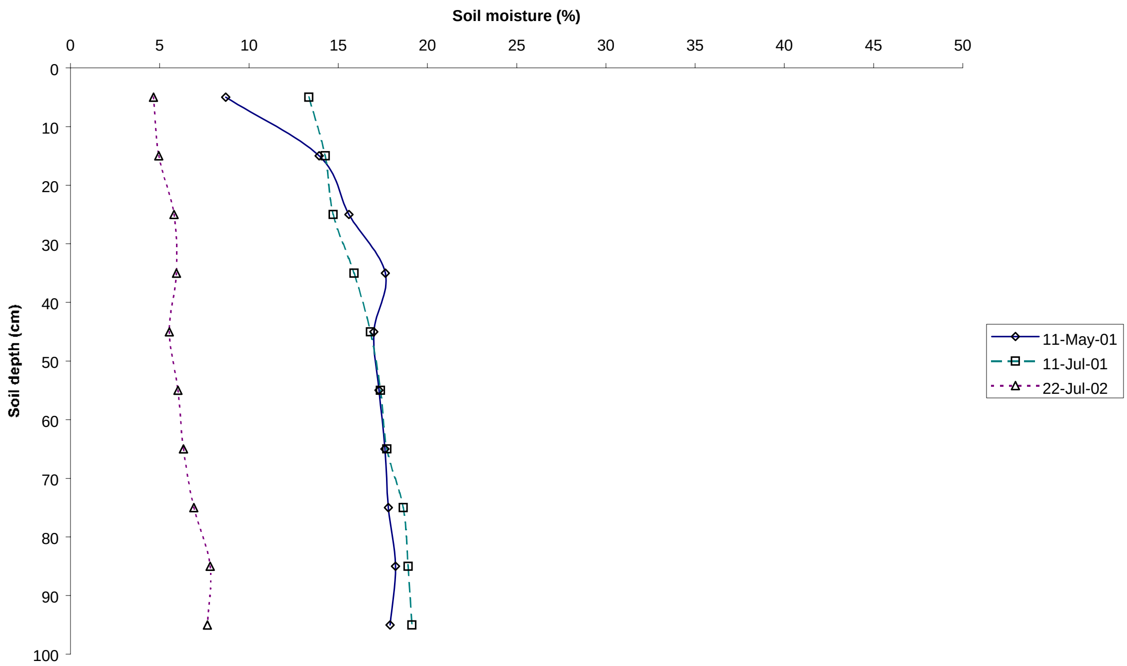
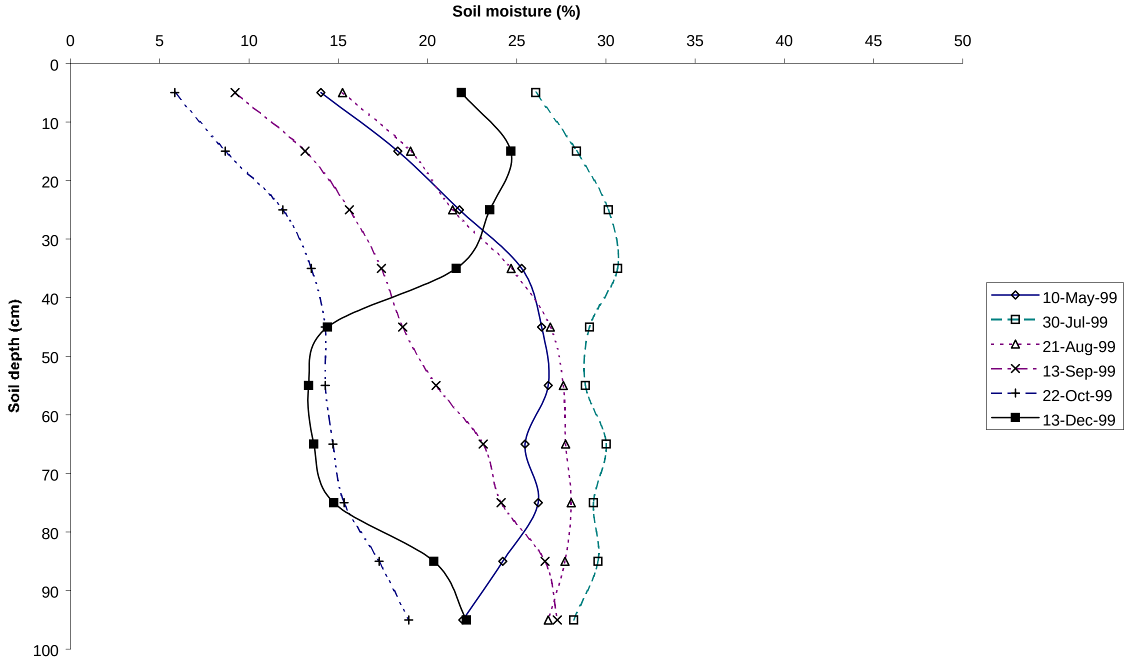
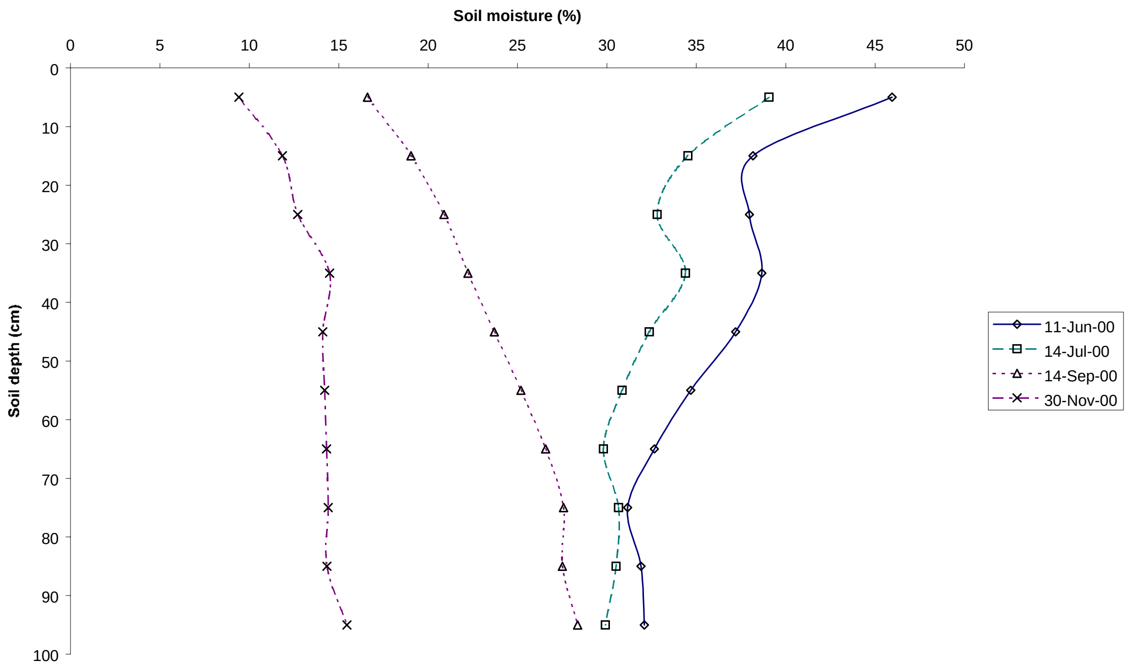


Figure 14. Site 4 soil moisture levels at a) June (◇), August 1999 (□) ,October (△), December 2000 (✕) and b) May (◇), July 2001 (□), July 2002 (△).

a)


Soil moisture (%)
0
5
10
15
20
25
30
35
40
45
50
Soil depth (cm)
0
10
20
30
40
50
60
70
80
90
100
10-May-99
30-Jul-99
21-Aug-99
13-Sep-99
22-Oct-99
13-Dec-99

b)


Soil moisture (%)
0
5
10
15
20
25
30
35
40
45
50
Soil depth (cm)
0
10
20
30
40
50
60
70
80
90
100
11-Jun-00
14-Jul-00
14-Sep-00
30-Nov-00

c)

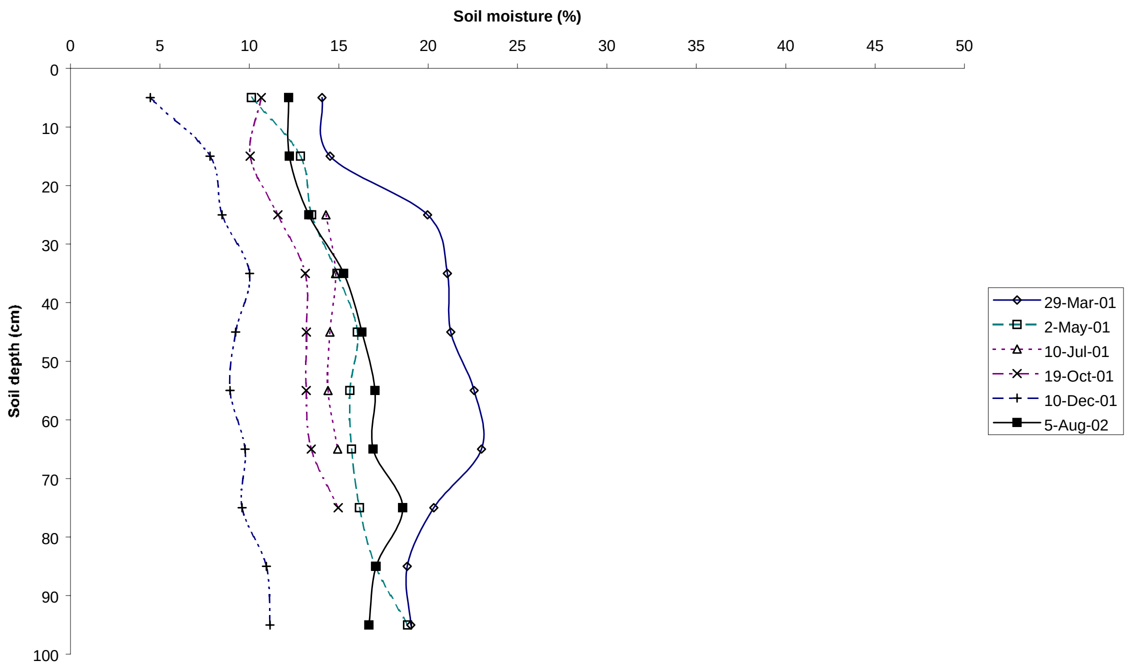
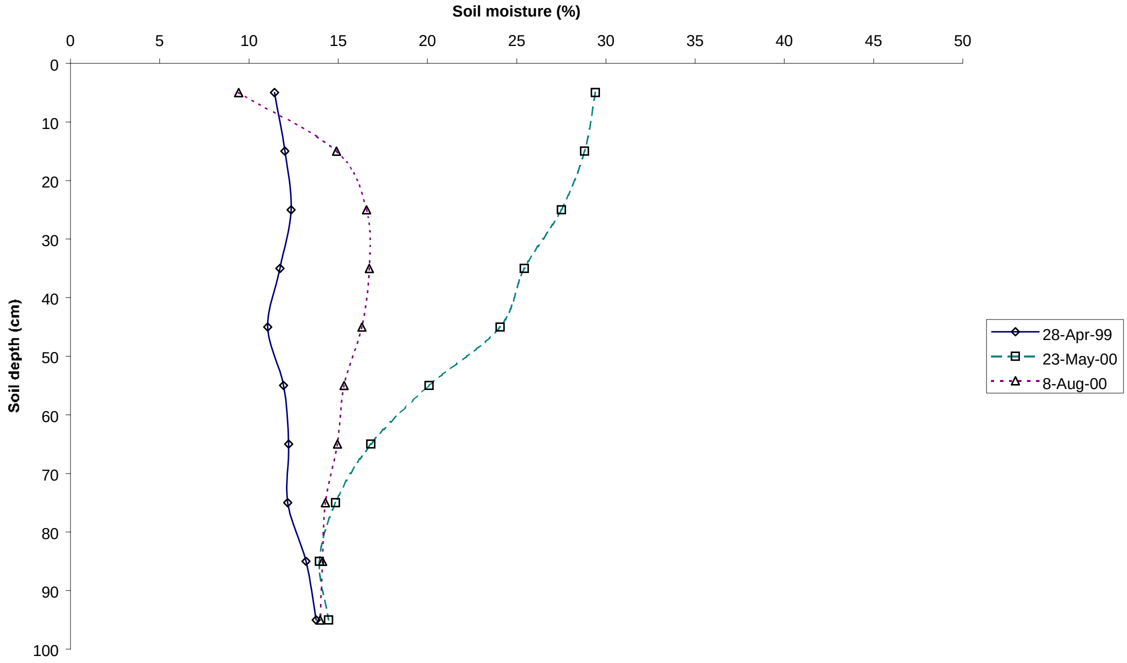


Figure 15. Site 5 soil moisture levels at a) May (◇), July (☐), August (△), September (✕), October (+), December 1999 (■), b) June (◇), July (☐), September (△), November 2000 (✕) and c) March (◇), May (☐), July (△), October (✕), December 2001 (+), August 2002 (■).

a)



b)

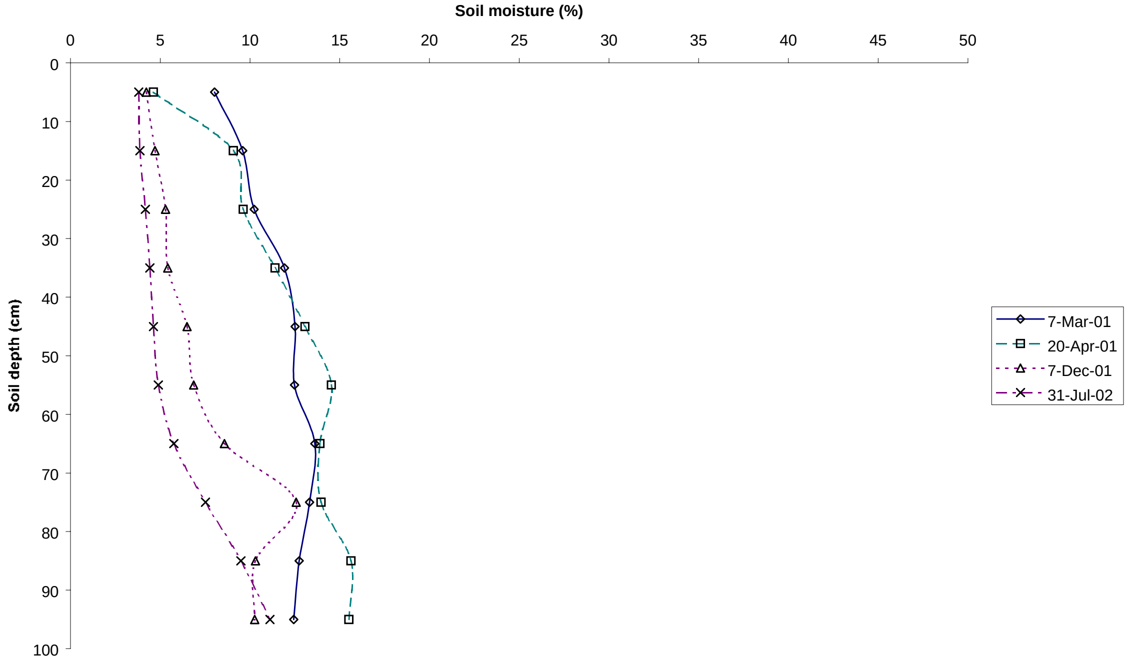
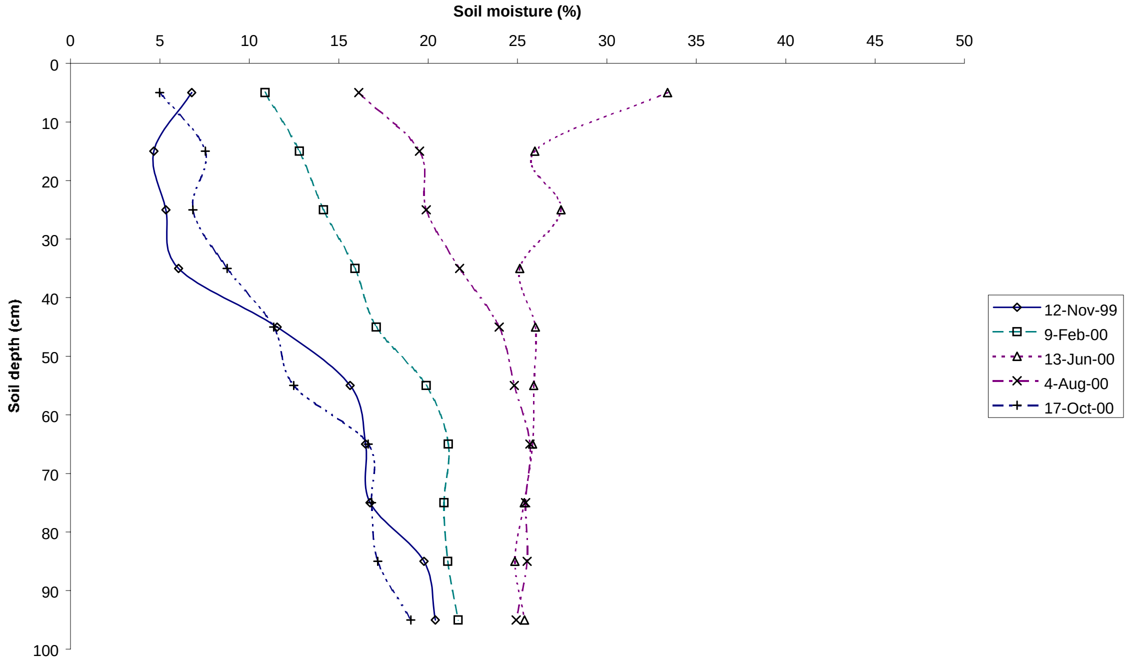


Figure 16. Site 6 soil moisture levels at a) April 1999 (◇), May (□), August 2000 (△), and b) March (◇), April (□), December 2001 (△), July 2002 (✕).

a)



b)

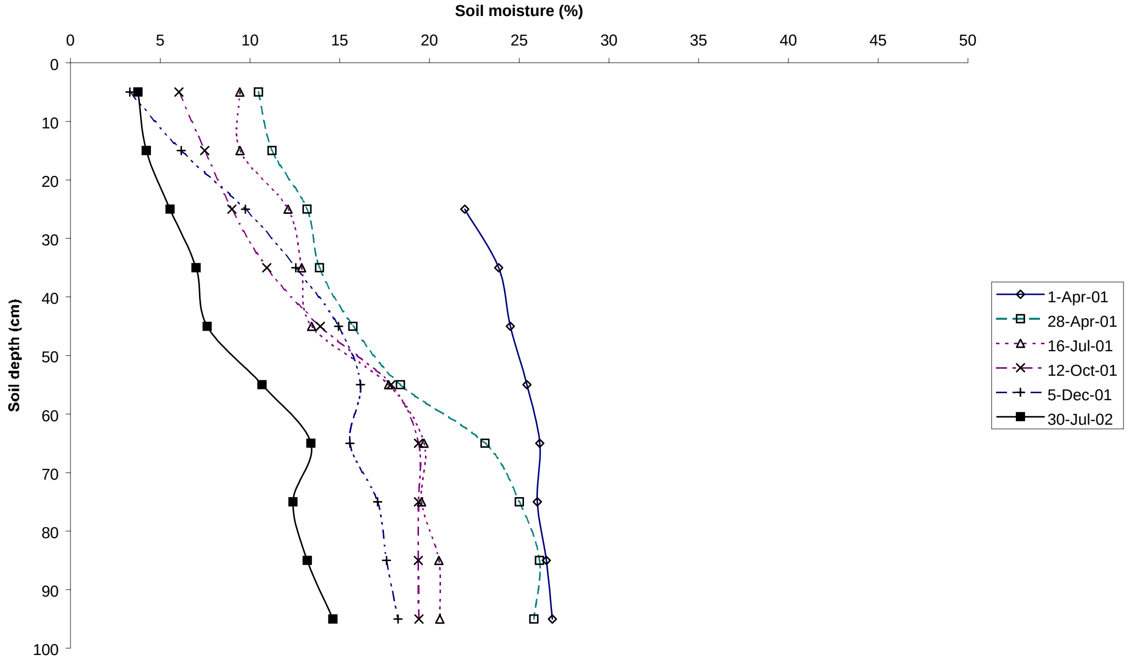
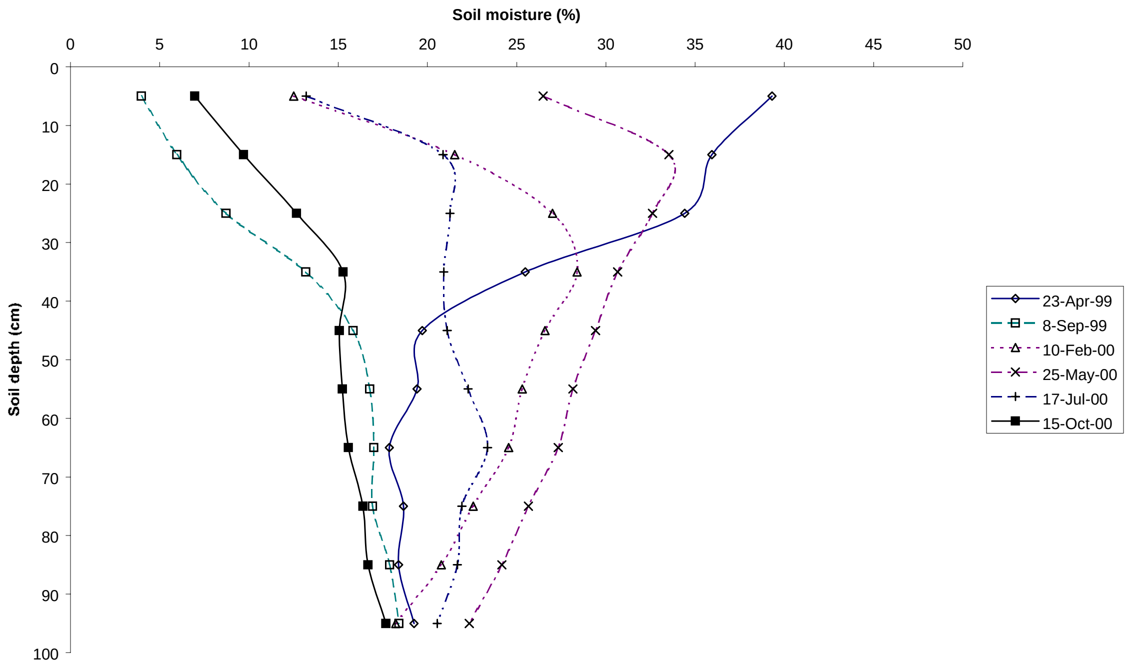


Figure 17. Site 7 soil moisture levels at a) November 1999 (◇), February (□), July (△), August (✕), October 2000 (+) and b) April (◇, □), July (△), October (✕), December 2001 (+), July 2002 (■).

a)



b)

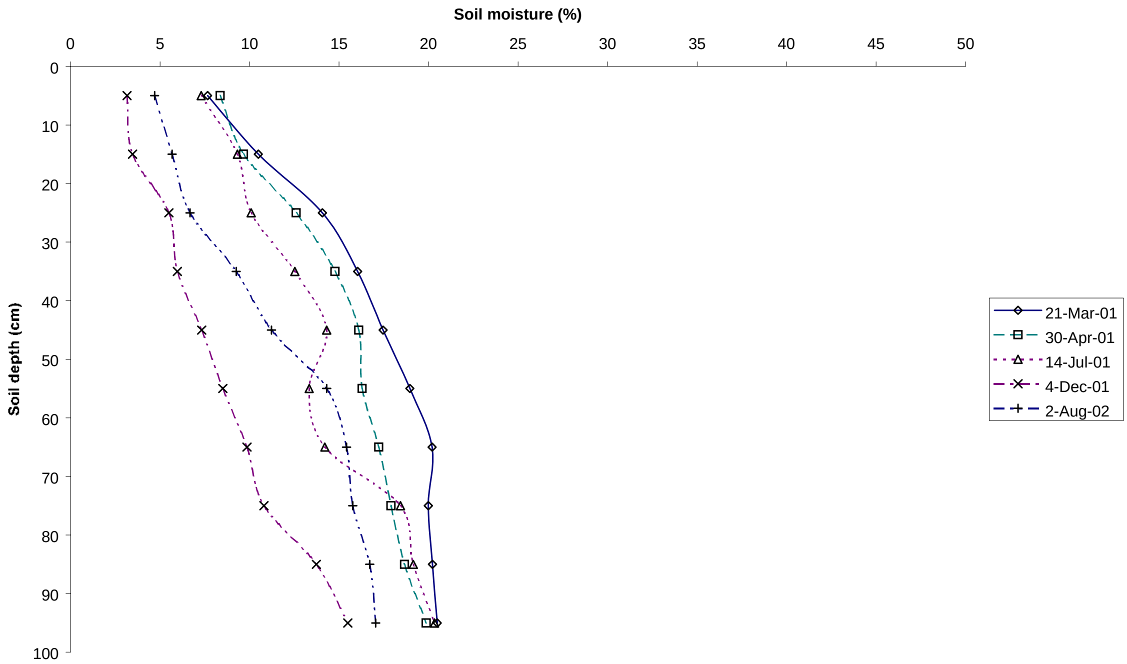
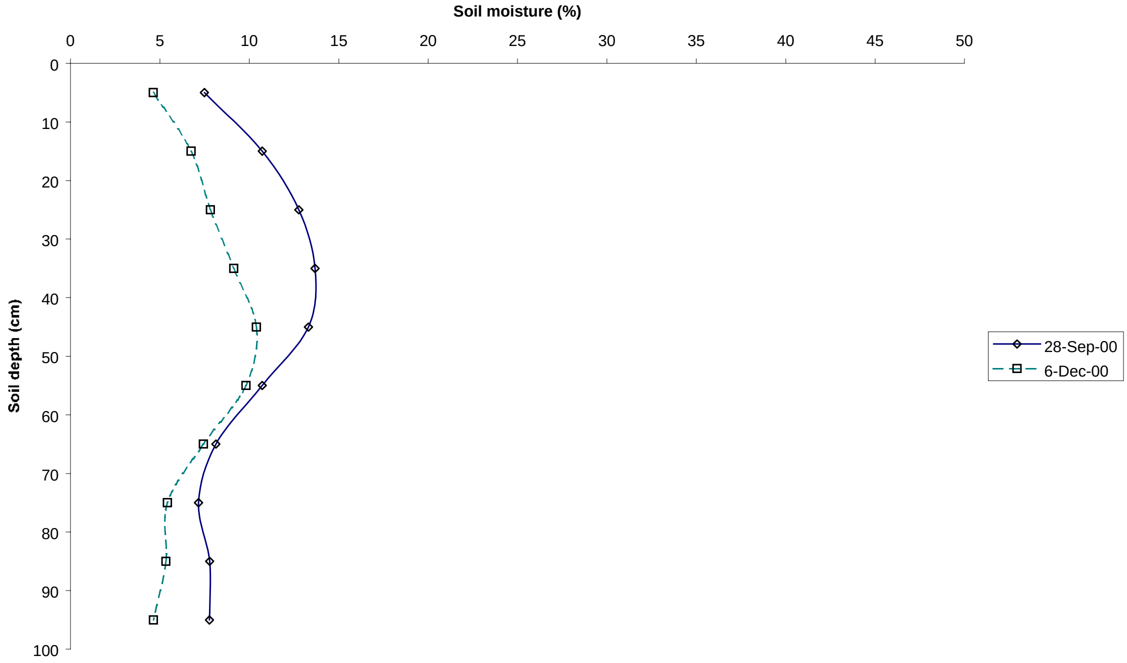


Figure 18. Site 8 soil moisture levels at a) April (◇), September 1999 (□), February (△), May (✕), July (+), October 2000 (■) and b) March (◇), April (□), July (△), December 2001 (✕), August 2002 (+).

a)



b)

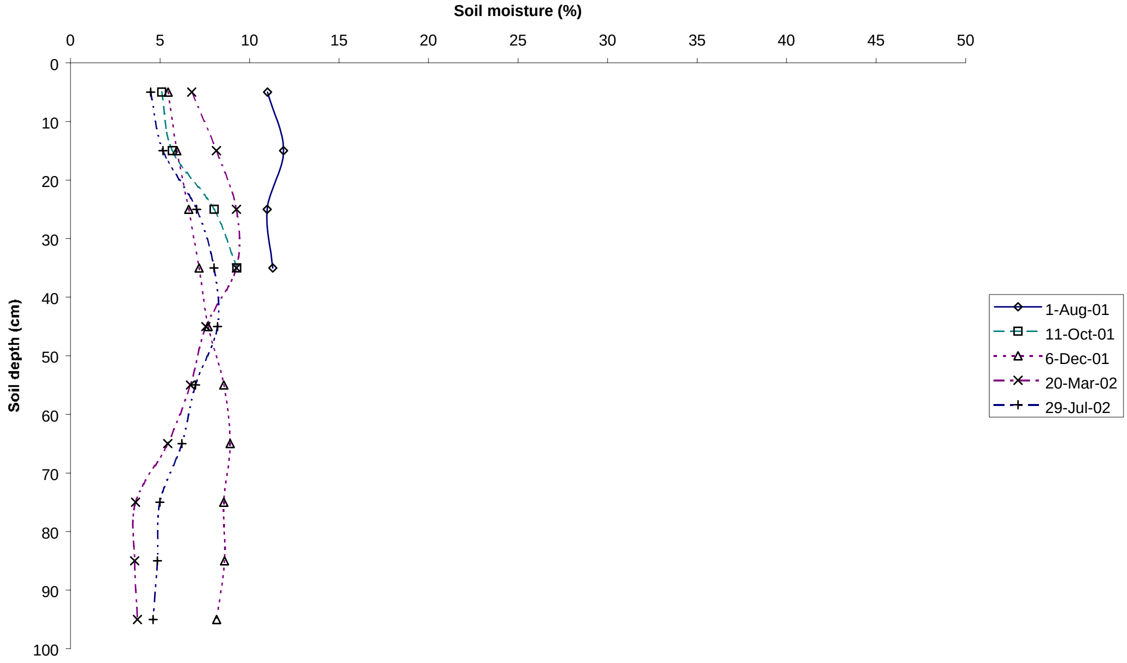
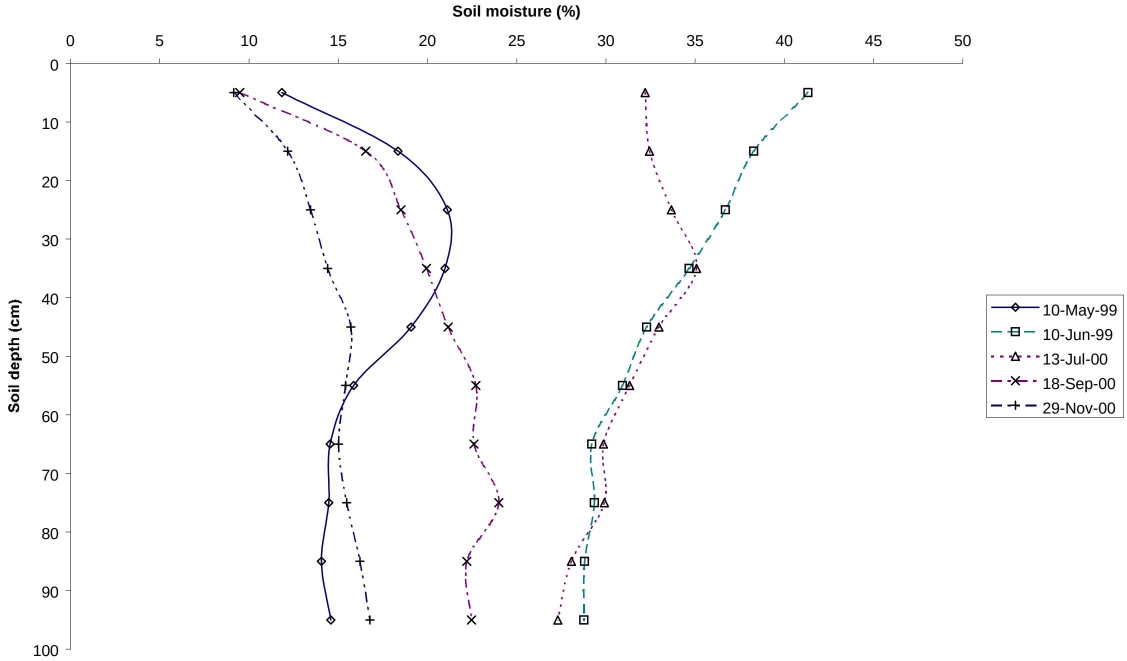


Figure 19. Site 9 soil moisture levels at a) September (◇), December 2000 (□) and b) August (◇), October (□), December 2001 (△), March (✕), July 2002 (+).

a)



b)

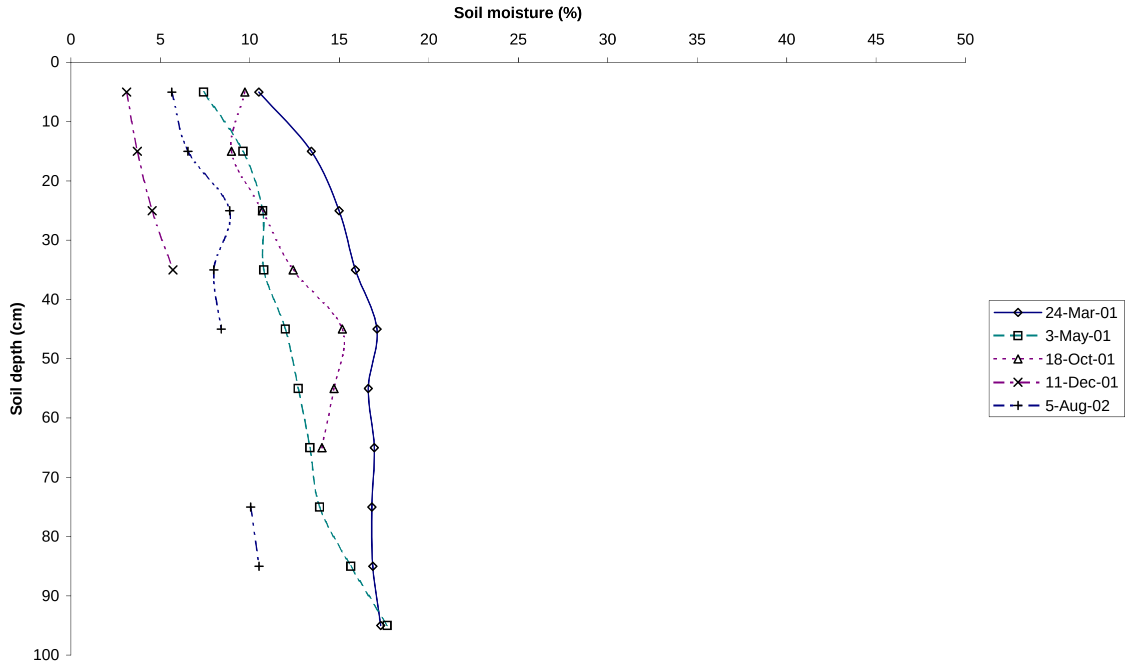
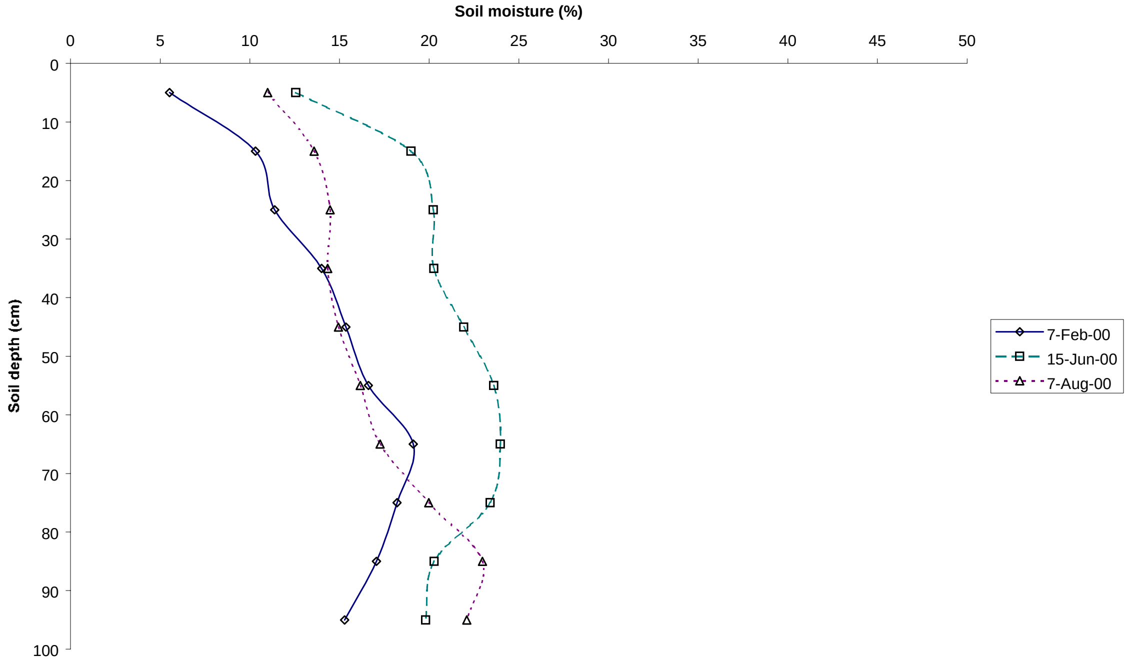


Figure 20. Site 10 soil moisture levels at a) May (◇), June 1999 (□), July (△), September (✕), November 2000 (+) and b) March (◇), May (□), October (△), December 2001 (✕), August 2002 (+).

a)



b)

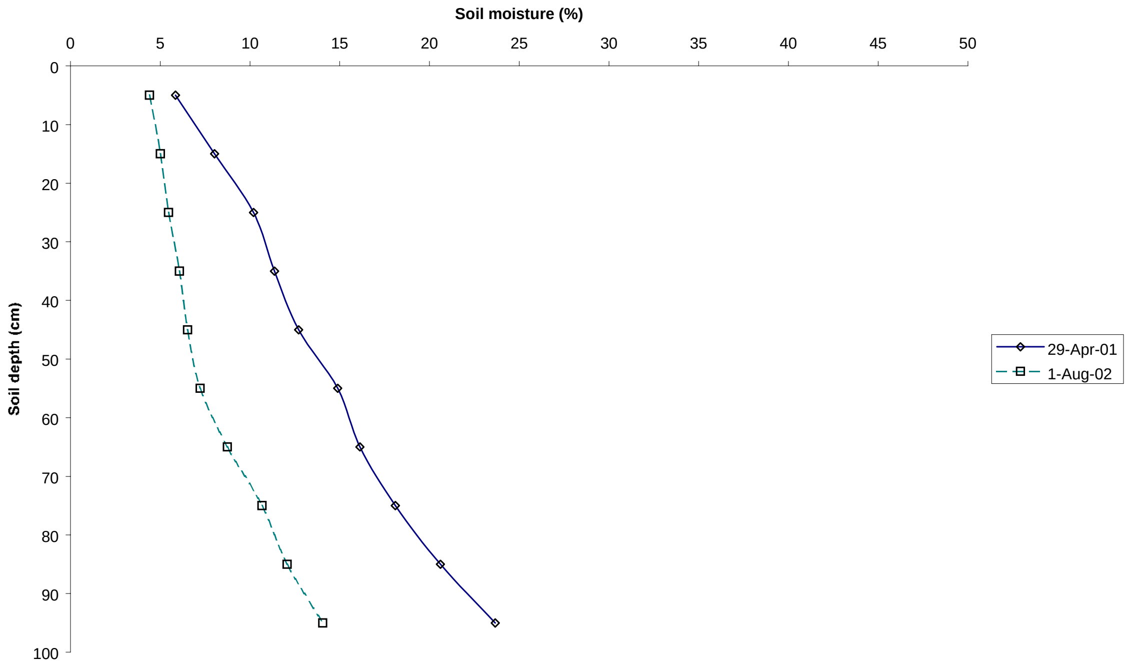
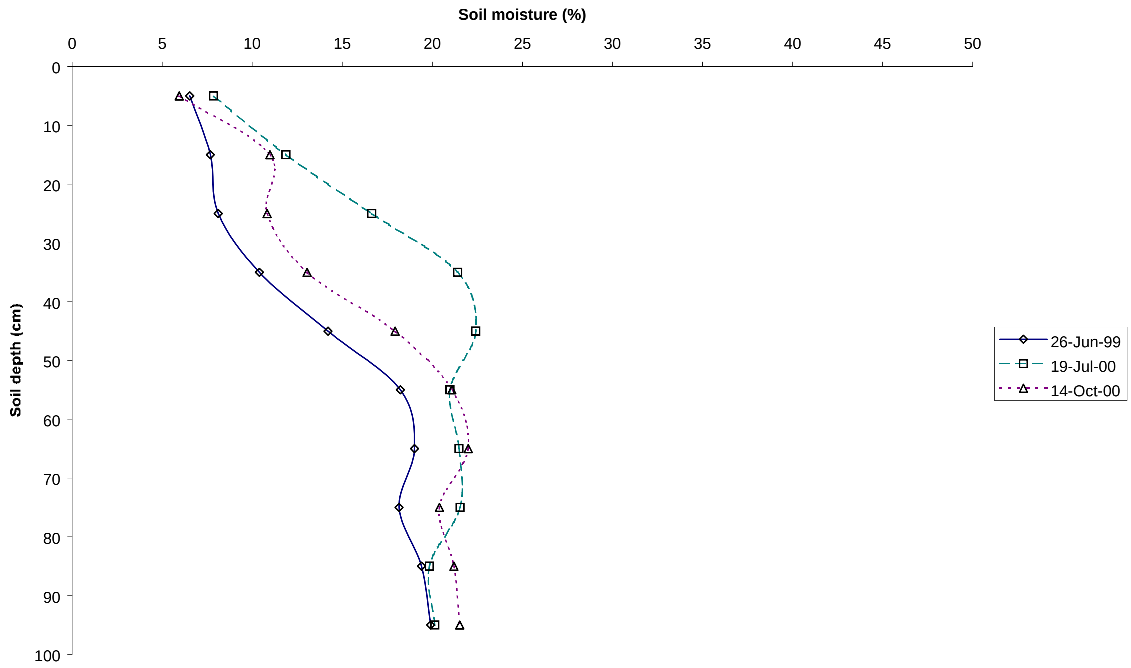


Figure 21. Site 11 soil moisture levels at a) February (◇), June (☐), August 2000 (△),and b) April 2001 (◇), August 2002 (☐).

a)



b)

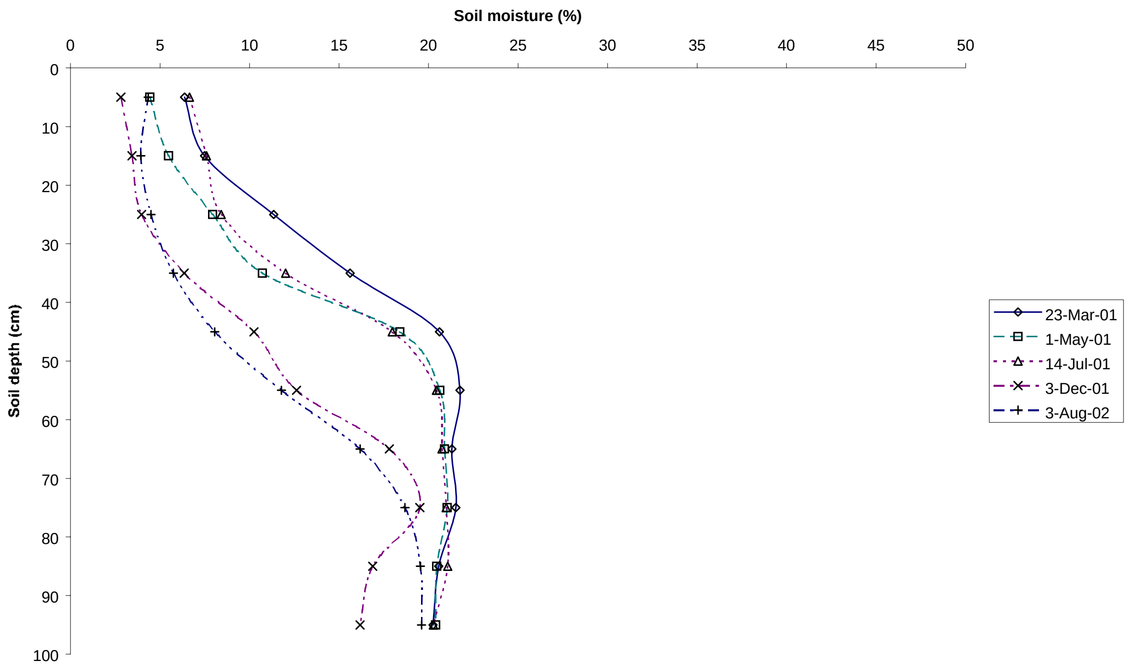
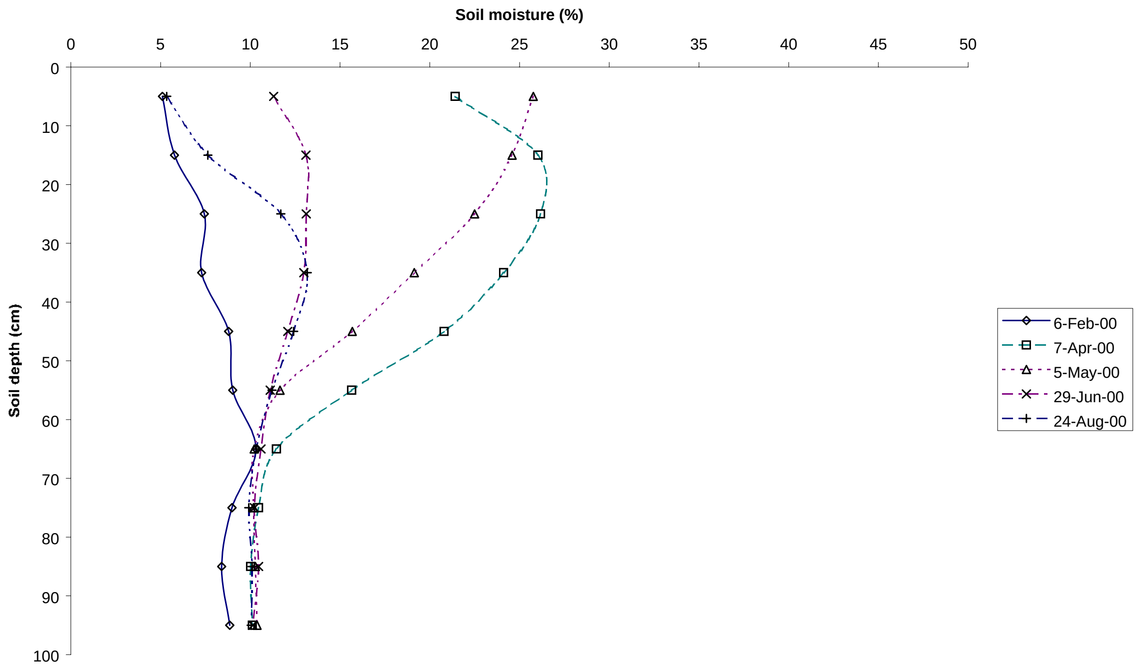


Figure 22. Site 12 soil moisture levels at a) June 1999 (◇), July (☐), October 2000 (△) and b) March (◇), May (☐), July (△),December 2001 (✕), August 2002 (+).

a)



b)

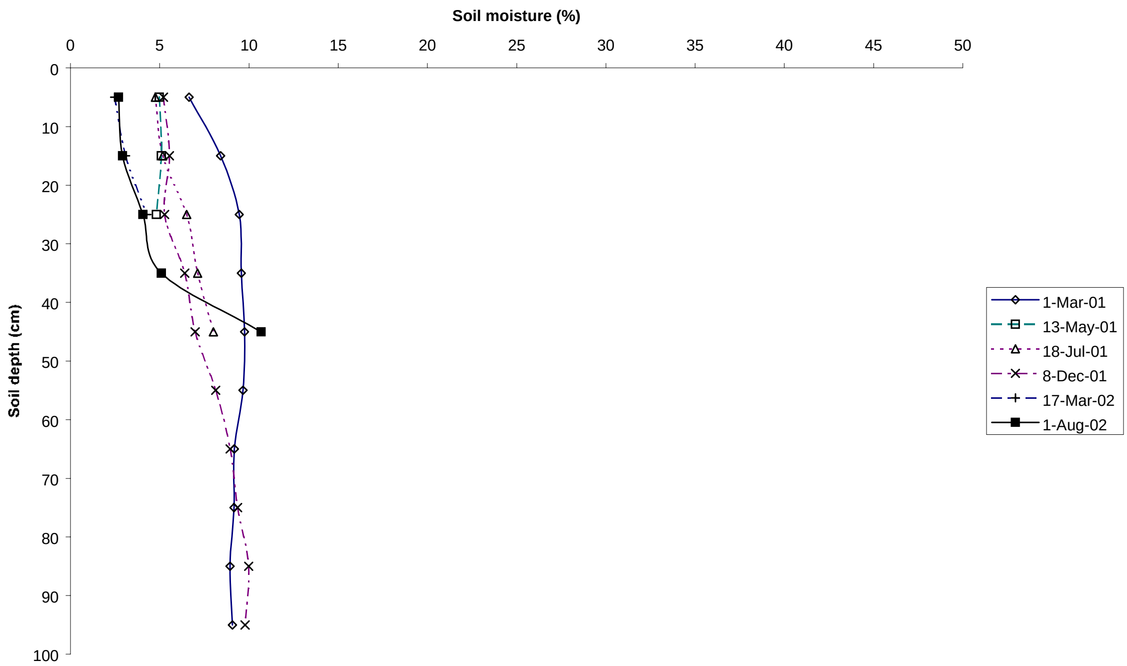
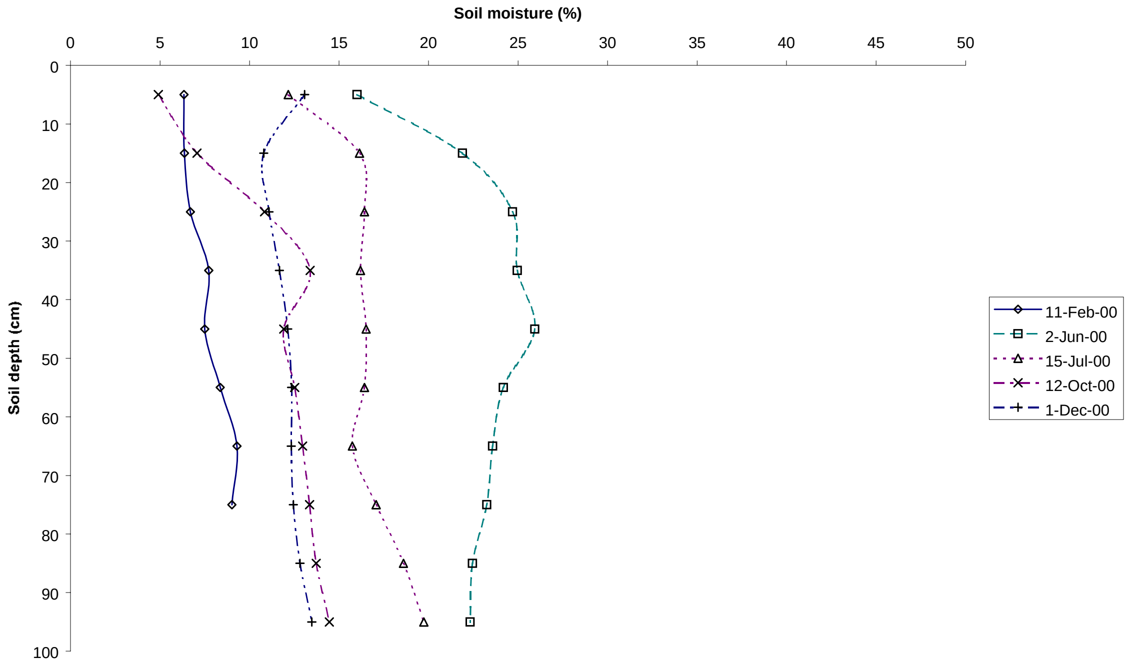


Figure 23. Site 13 soil moisture levels at a) February (◇), April (□), May (△), June (×), August 2000 (+) and b) March (◇), May (□), July (△), December 2001 (×), March (+), August 2002 (■).

a)



b)

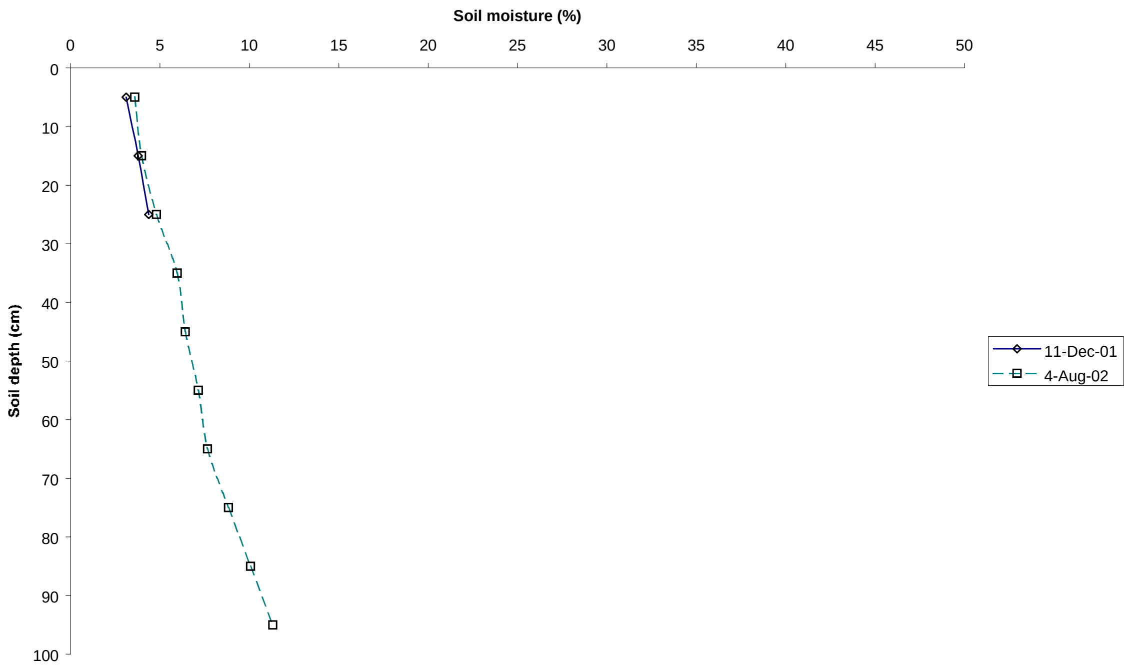
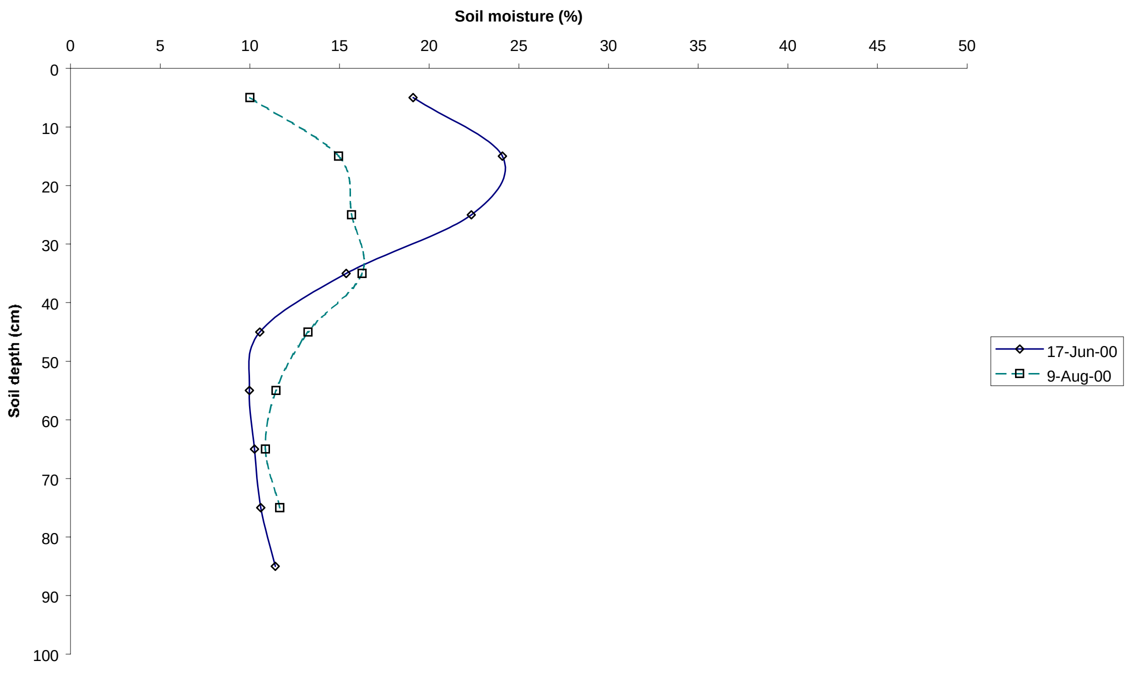


Figure 24. Site 14 soil moisture levels at a) February (◇), June (□), July (△), October (✕), December 2000 (+) and b) December 2001 (◇), August 2002 (□).

a)



b)

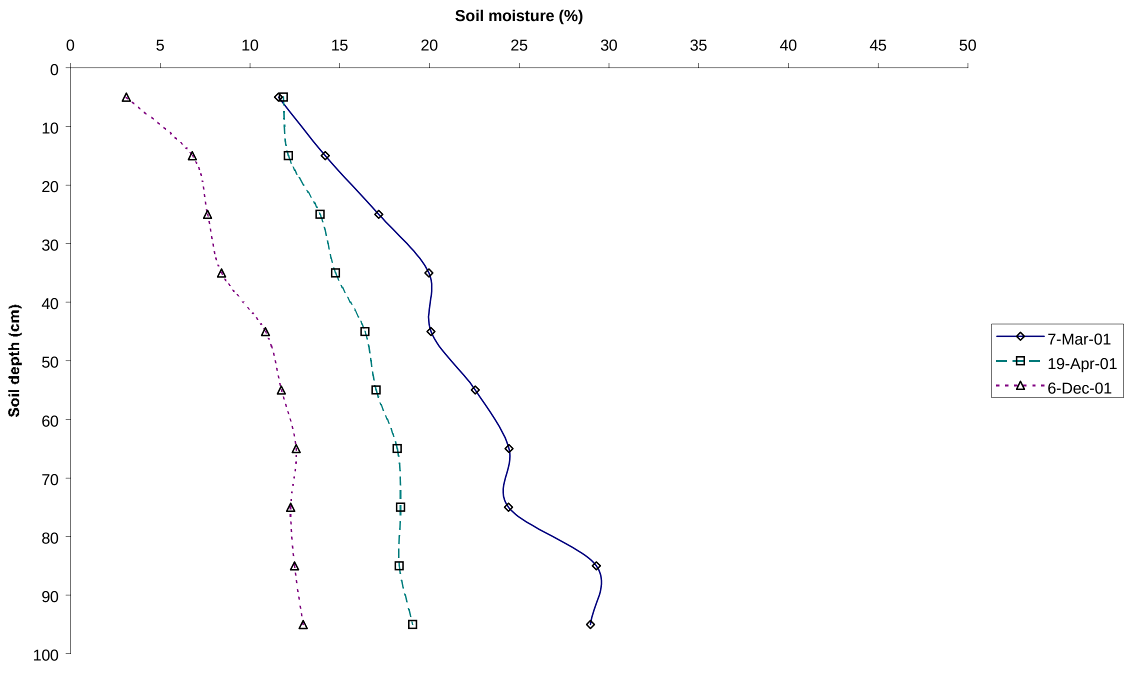
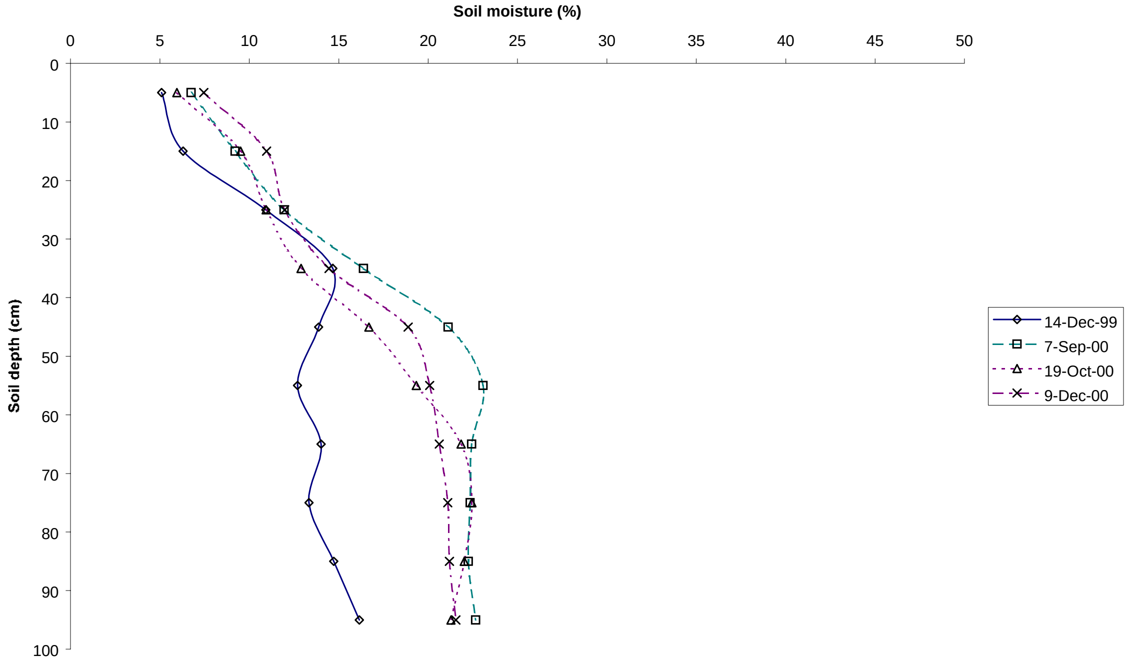


Figure 25. Site 15 soil moisture levels at a) June (◇), August 2000 (□) and b) March (◇), April (□), December 2001 (△).

a)



b)

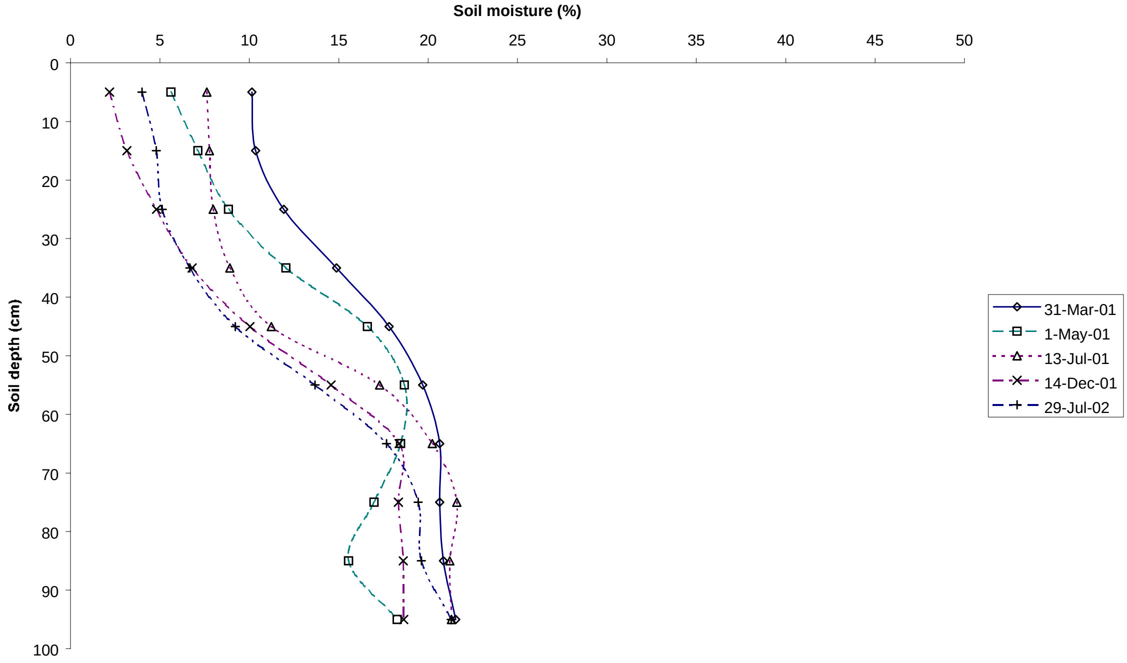
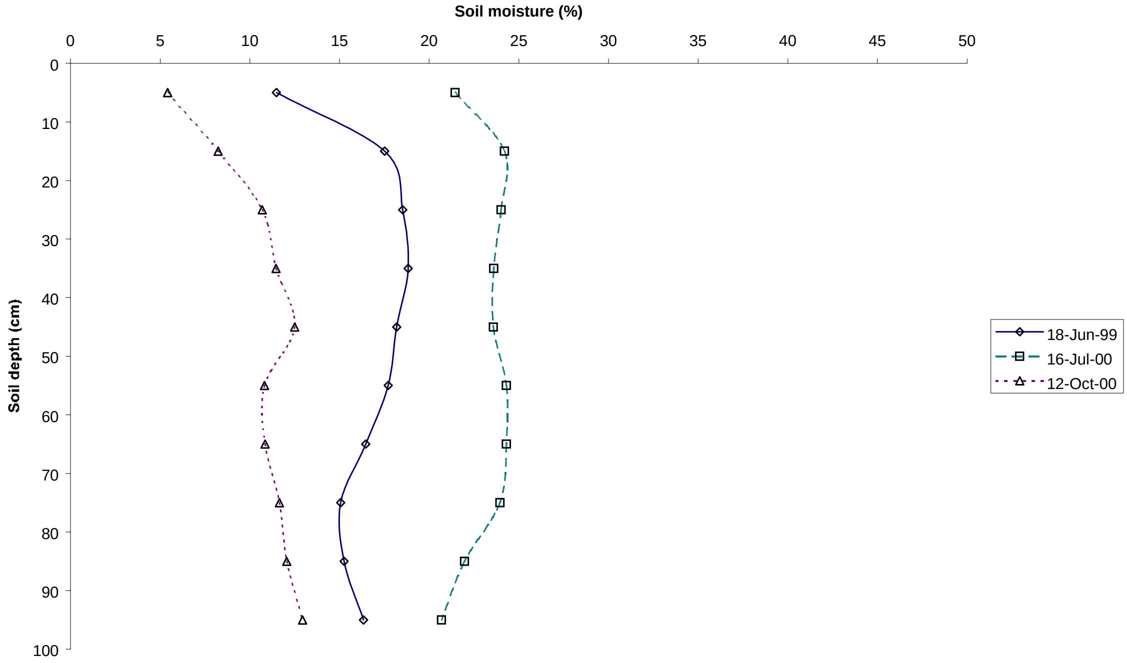


Figure 26. Site 16 soil moisture levels at a) December 1999 (◇), September (☐), October (△), December 2000 (✕) and b) March (◇), May (☐), July (△), December 2001 (✕), July 2002 (+).

a)



b)

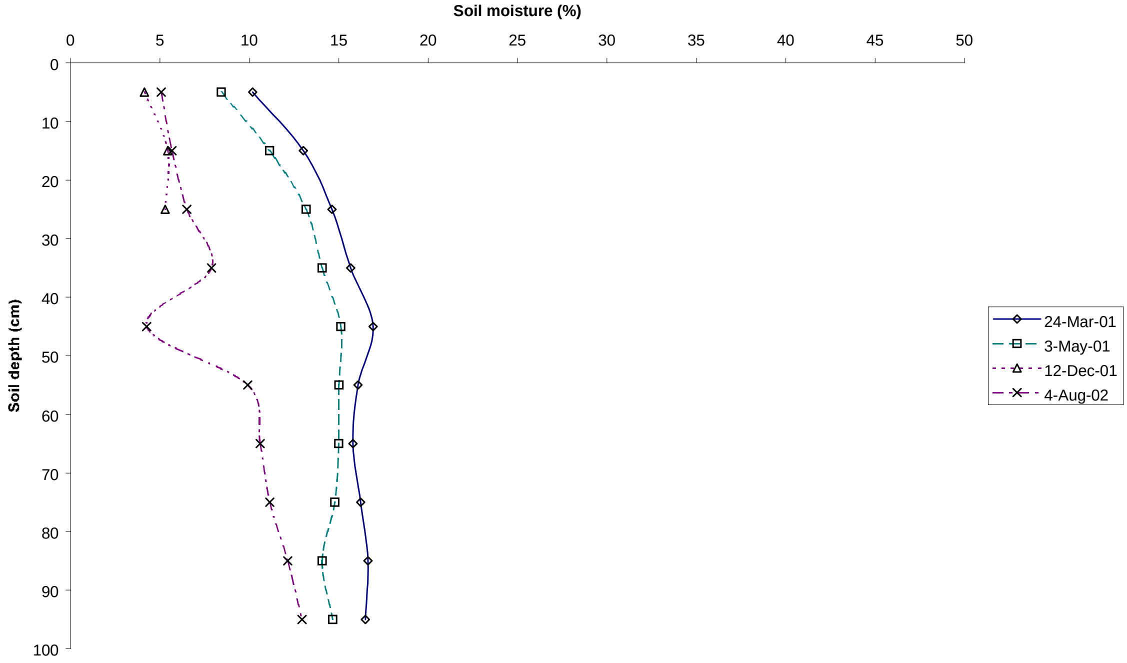


Figure 27. Site 17 soil moisture levels at a) June 1999 (◇), July (☐), October 2000 (△) and b) March (◇), May (☐), December 2001 (△), August 2002 (✕).

Pasture relationships

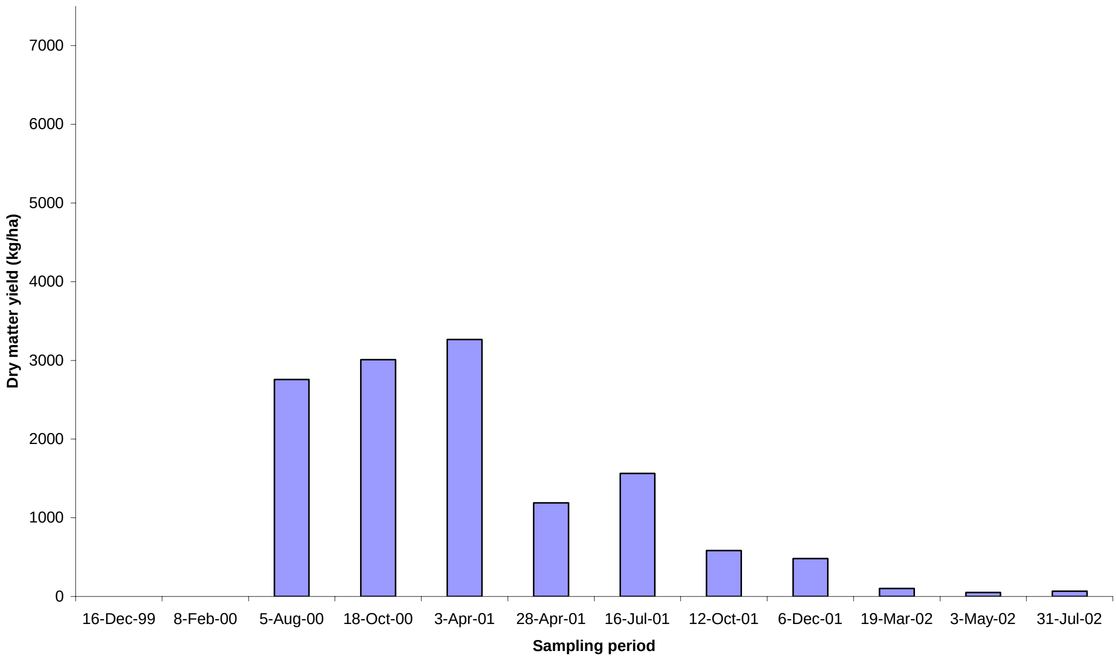
Pasture yields

Pasture yields generally reached a peak towards the end of 2000, with rapid initial yield increases in the first quarter (Figure 28 a to 28 q) following the flood events of the 1999/2000 summer. This was followed by a declining phase during the extreme below average rainfall conditions through late 2001 and 2002 (Table 5). The highest yield recorded during the monitoring period was 7009 kg/ha at Site 5 (Figure 28a) in September 2000. The lowest recorded yields have consistently been in 2002, with sites generally exhibiting yields of less than 100 kg/ha. The lowest was estimated as 9 kg/ha at Site 14 (Figure 28n). Most properties were largely de-stocked by August 2002 in response to the poor available feed levels.

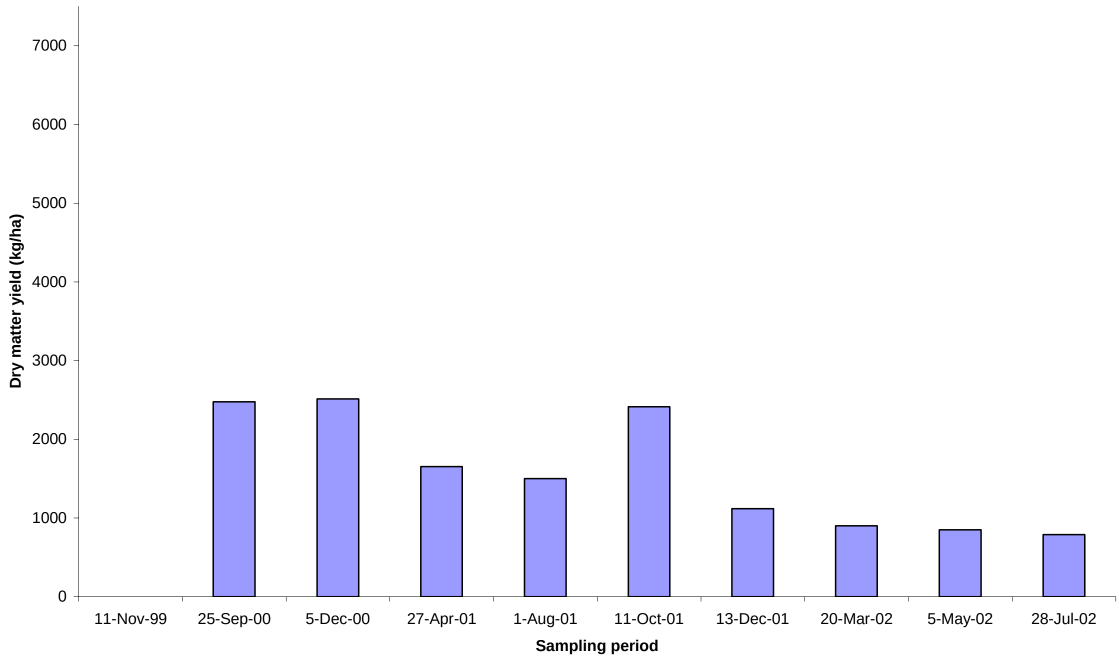
Cooper Creek sites (Sites 4, 5, 10, 14, 17; Table 3) have had the highest yields on average, with sites within the Diamantina (Sites 2, 3, 8, 9, 12, 13, 16) and Georgina (Sites 1, 6, 7, 11, 15) at similar levels to each other, possibly reflecting the flood frequency experienced between early 1999 and August 2002. In general, C1 bluebush site yields (Sites 1 to 5) have been greater than C1 lignum (Sites 5 to 10), C2 (Sites 11 to 14) or C3 (Sites 12 to 17) Land Systems.

Substantial rainfall (often quoted as 100 mm or more by graziers) is generally required to initiate a pasture response through the germination of plants on the heavy clay soils of the floodplains. This will presumably depend on existing soil moisture levels, and potentially on the duration of cloud cover and humidity. Site 13, on the Diamantina, received in excess of 50 mm rainfall over the 2001/2002 summer, but pasture yield continued to decline (Figure 28m). Rain would be expected to lengthen the growing season when following a flood event, but this situation has not been recorded as yet. This aspect of the production system requires further consideration and study.

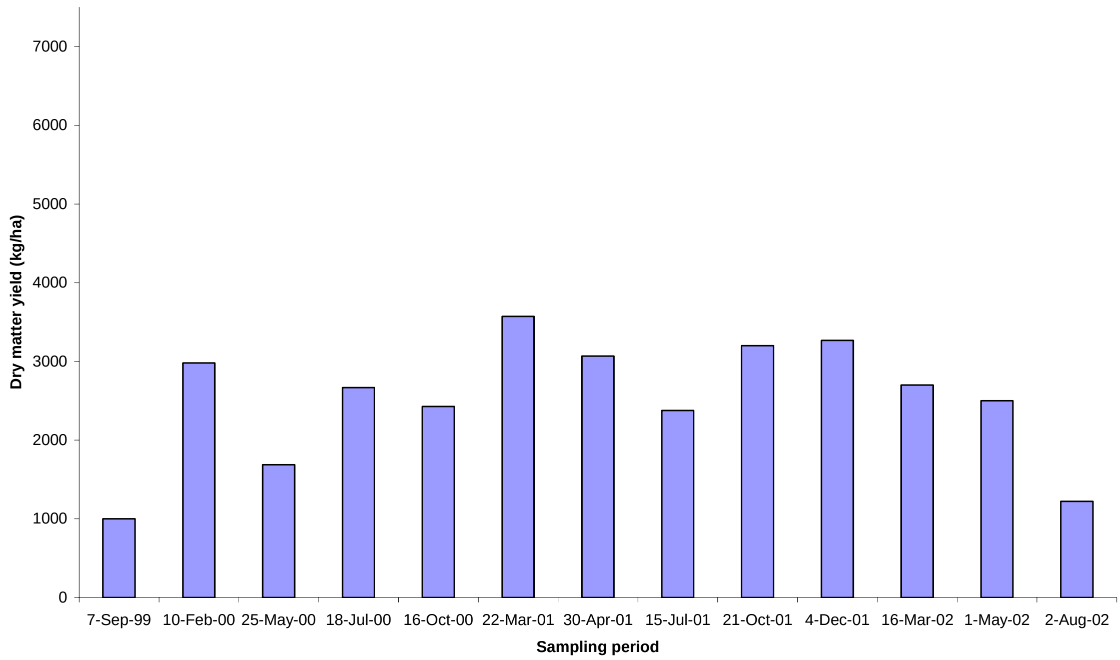
a) Site 1



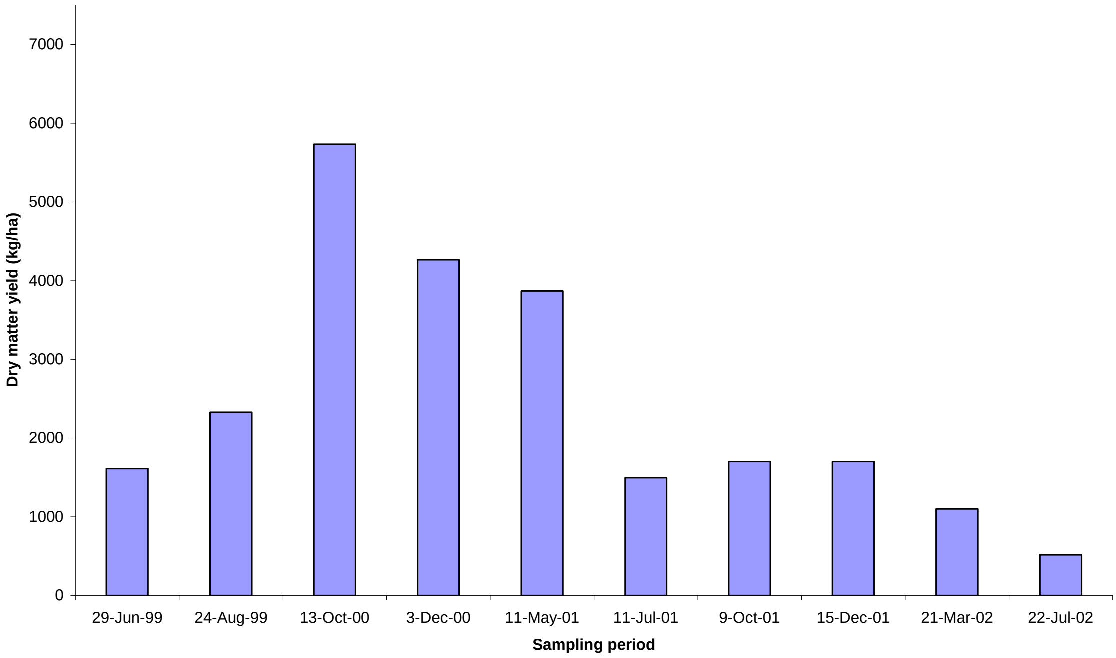
b) Site 2



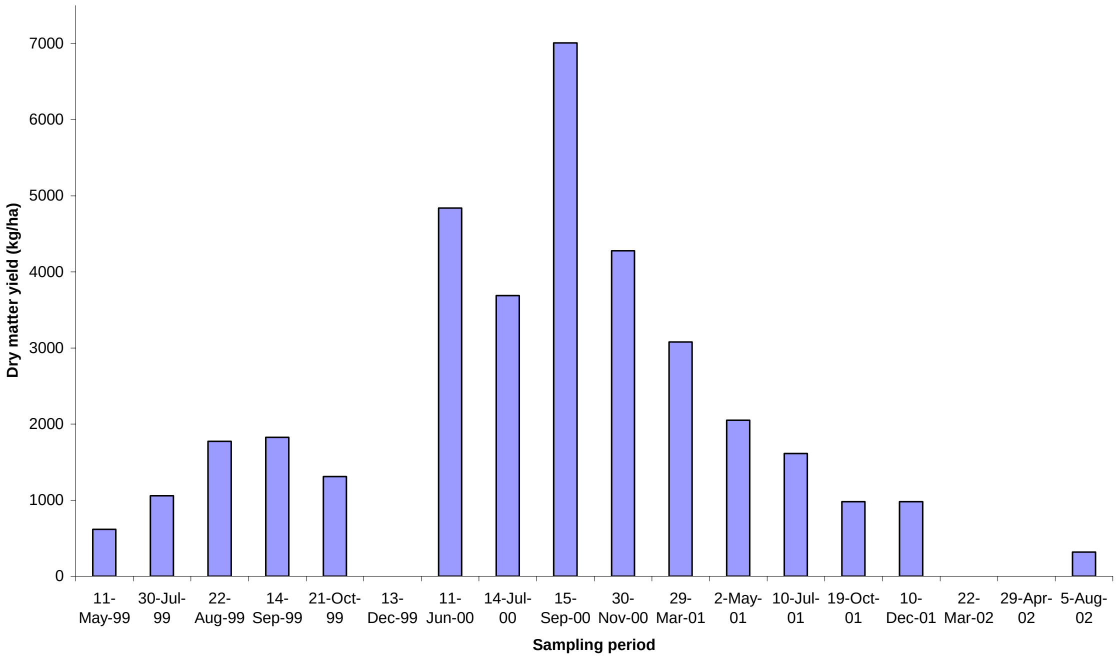
c) Site 3



d) Site 4



e) Site 5



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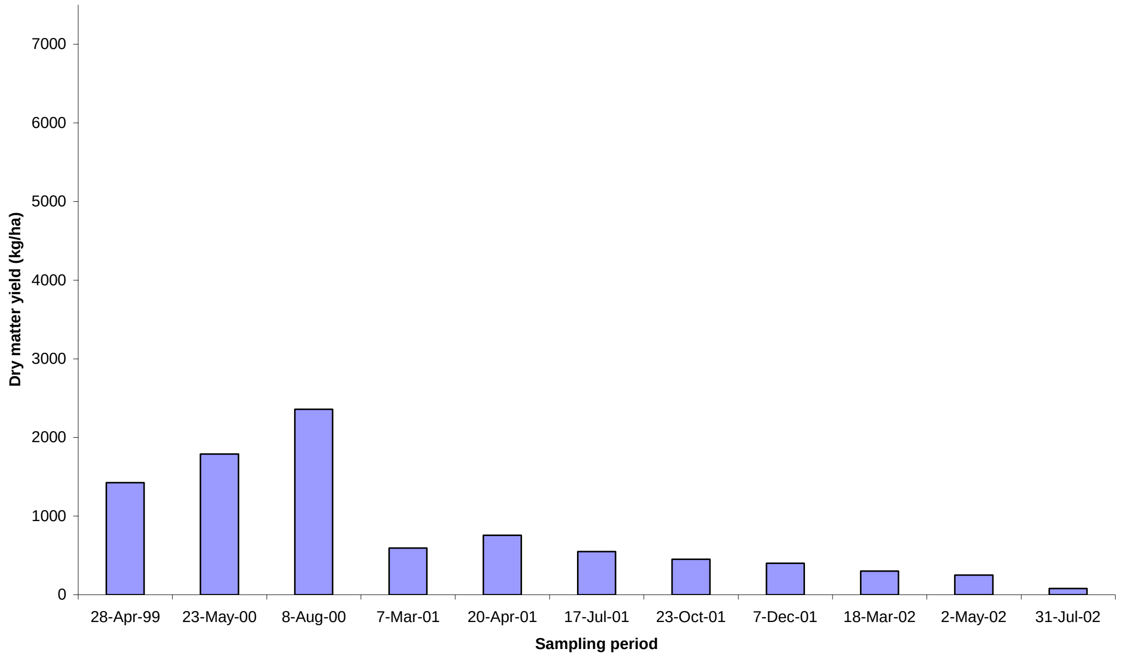

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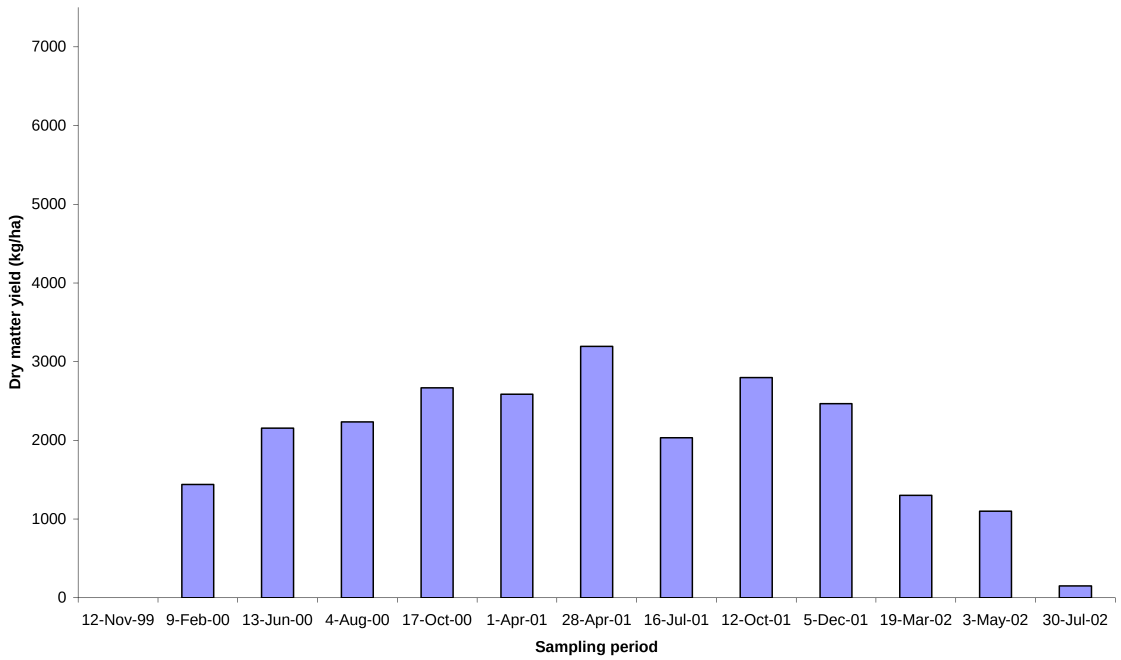

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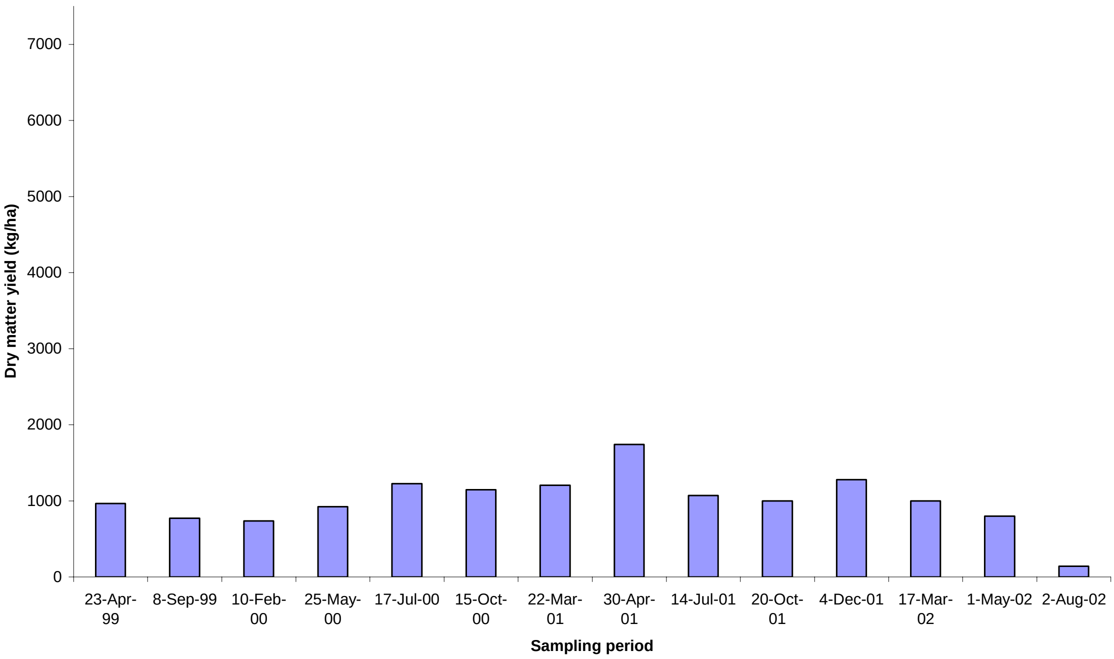

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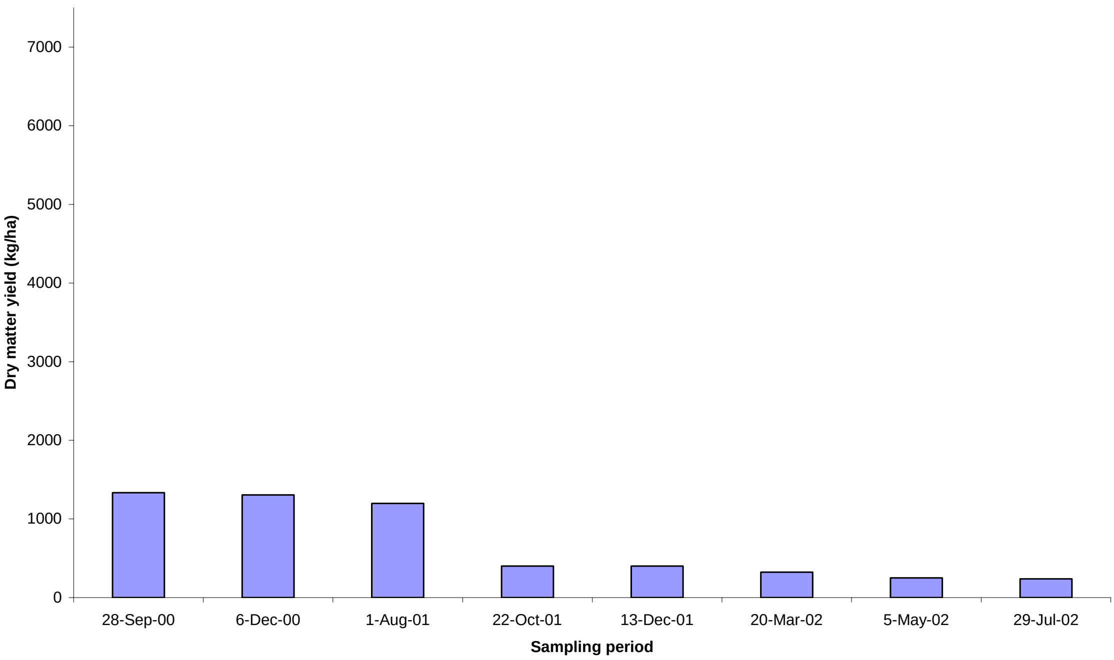

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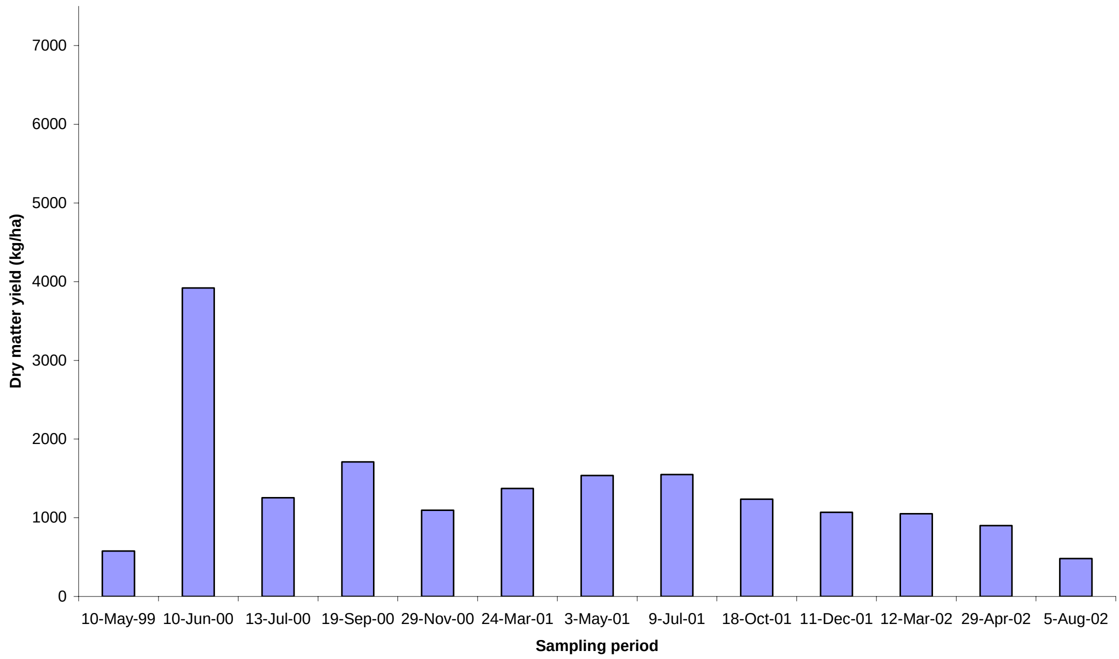

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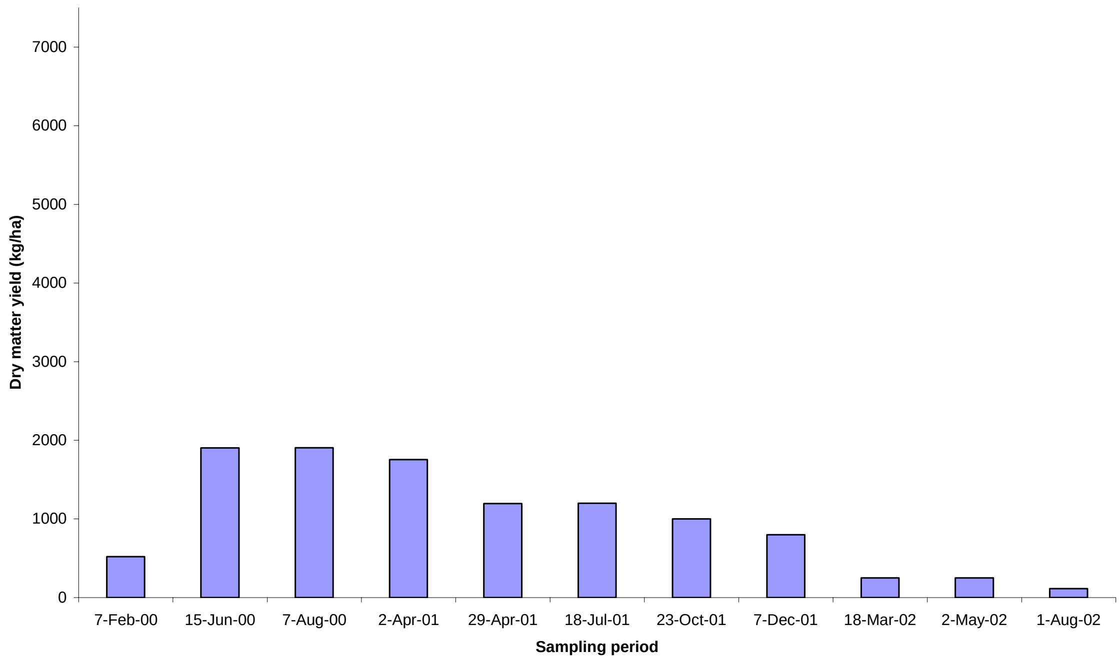

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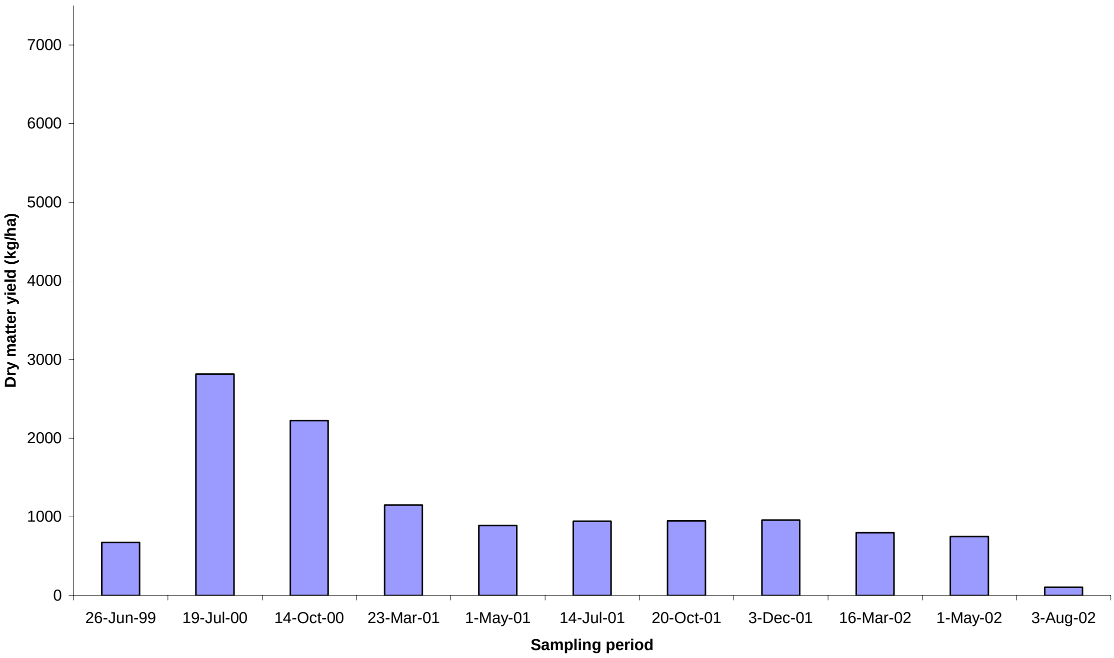

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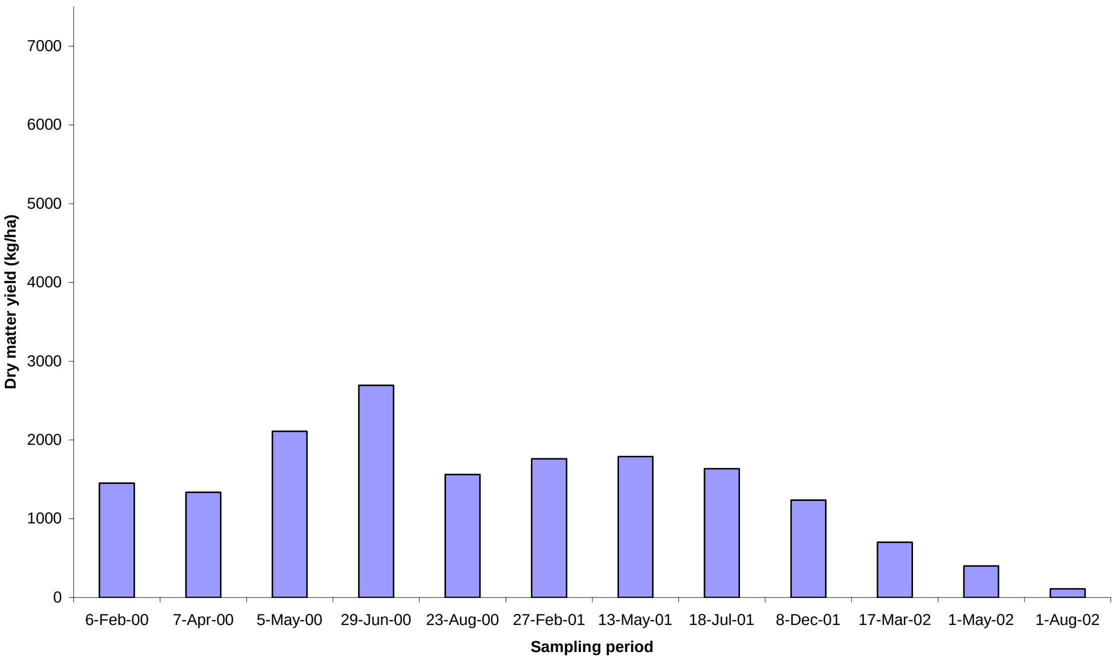
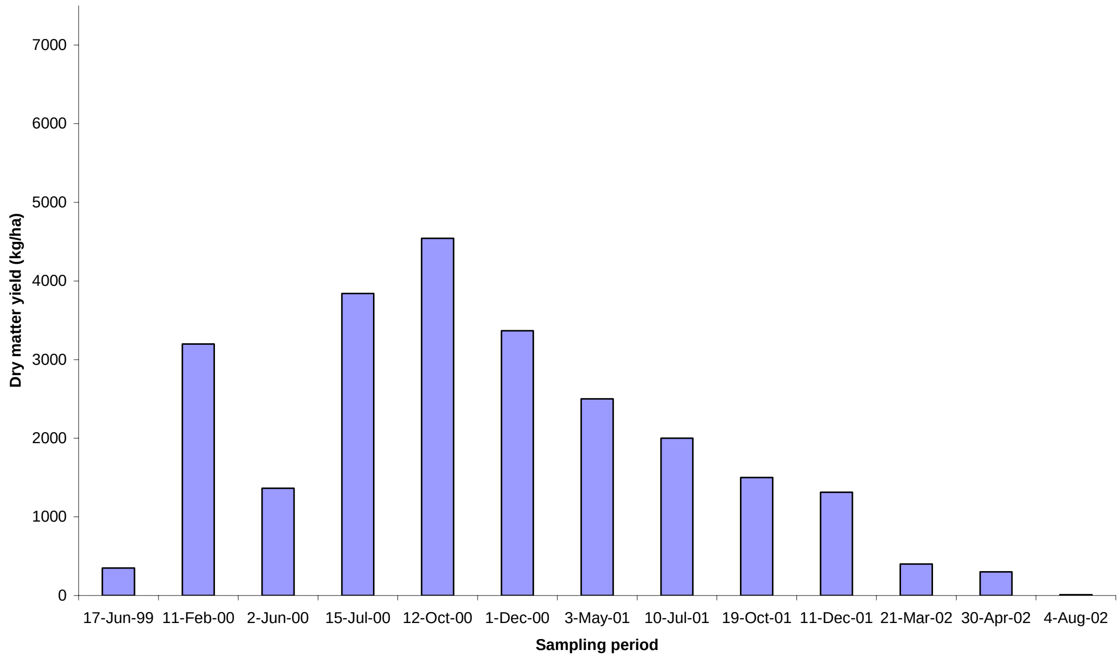
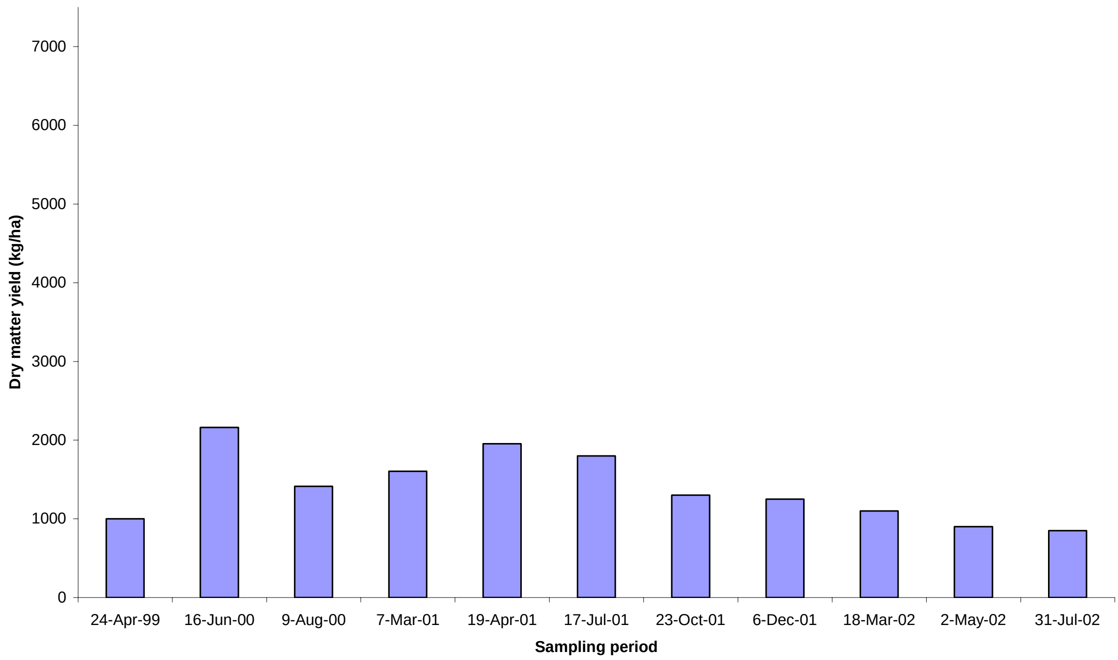


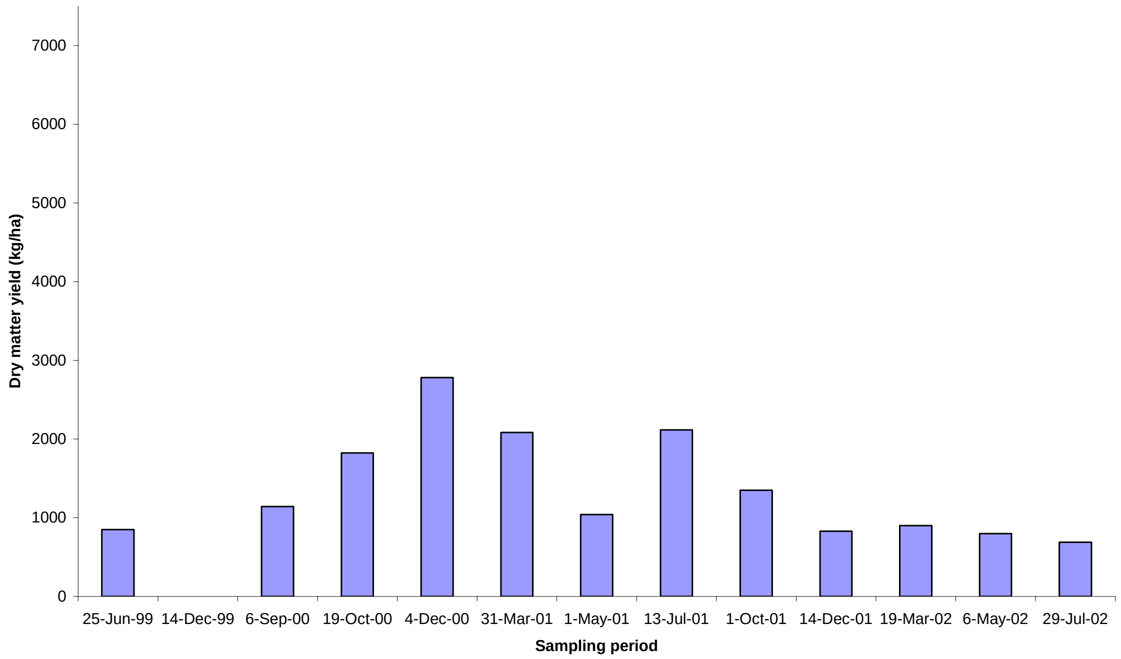
n) Site 14



o) Site 15



p) Site 16



q) Site 17

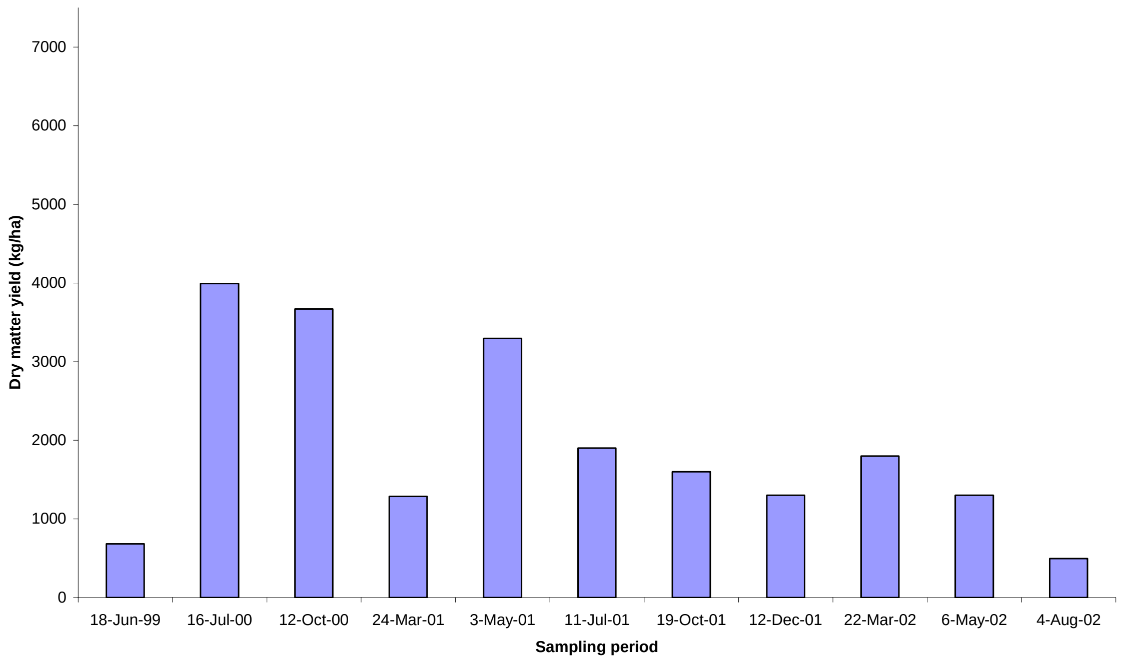


Figure 28. Pasture yield (kg/ha of total standing dry matter) at a) Site 1 through to q) Site 17 during the recording period (1999 to August 2002).

Pasture yield composition

C1B and C3 site yields were dominated by bluebush (on average, 56 and 28% respectively) and forbs (41 and 43%) for most sampling periods (Figure 29a, d). Whilst the contribution of forbs to yields tended to be high for all Land Systems at most times, bluebush contributed only 11% (on average across all dates) to C1L yields and was not present within C2 site yields.

C2 site yields were dominated by annual grasses and forbs (on average, 36 and 58% respectively), with a small (7% on average) proportion of perennial grasses present (Figure 29c). This probably reflects the low frequency of flooding within the C2 Land System and a potentially hostile environment for the establishment of perennial plants.

The greatest proportion of perennial grass (primarily rat's tail couch, *Sporobolus mitchellii*) was within the C1L sites (28% on average, Figure 29b). C1L sites also contained the greatest proportion of other plants (13% on average), a group dominated by sedges and nutheads. Given the general preference of lignum and sedges for low lying and frequently flooded locations, this association suggests a tolerance of, or preference for, similarly moist conditions for rat's tail couch.

Other plants contributed 5% (on average) to C1B site yields but were absent from C2 and C3 sites.

Overall, the plant group compositions appear to demonstrate the general trend of flood frequency and duration being C1L>C1B>C3>C2. This is consistent with the Land System flood frequencies described in Table 1 and with the findings of other authors (e.g. Capon 1999).

The differences in plant group compositions and flooding potential between C1B and C1L sites justifies their separate sampling based on bluebush or lignum dominance and suggests averages across C1 sites may be meaningless.

The differences in plant group compositions and flooding potential overall suggest different management strategies may be appropriate for the different Land Systems. In general terms, country dominated by perennial plants both respond differently to increased soil moisture and require different grazing management to country dominated by annual plants. In the case of rat's tail couch, however, its apparent low palatability and ensuing low grazing pressure suggests no need for special grazing management to ensure its continued presence. This also suggests that, despite yield composition differences, C1L and C1B pasture sustainability can be achieved through similar management strategies.

Bluebush, on the other hand, is a key perennial species for both cattle production (as browse) and presumably for the maintenance of the pasture and soil resource. Given this, we need to know more about its biology, physiology and lifecycle, and especially a guide to safe utilisation rates and key times of stress to ensure its sustainable use. An accurate estimation of bluebush contribution to yields is also needed. Sites with yields dominated by bluebush are confounded by the proportion of bluebush that is unproductive stem, particularly during dry periods. Whilst it can be assumed that senesced stem bears the next season's useful browse, it contributes little to currently available forage. Higher total yields at a small number of sites are based on un-available bluebush stem, rather than on useful fodder.

Useful bluebush yield (defined as small stem and leaf) was estimated from site photographs. This was compared with measured bluebush yields to derive the proportion of available bluebush (Figure 30). This information should be treated as a guide to the available bluebush on offer, rather than as the definitive answer at this stage. Apart from 1999 on the Cooper, the general trend was for the proportion of available bluebush to peak in 2000 and steadily decline through to the present (Figure 30). It is probable that the 100% available yield derived for the Cooper in 1999 is based on a low incidence of bluebush plants at Site 5, and therefore reflects a difference in estimating useful bluebush yield from photographs with a higher apparent plant density. This could be rectified through sub-sampling bluebush into useful and stem categories during harvesting, negating the need to provide estimates from site photographs. There is also a need to test the Adelaide method (a field technique for estimating shrub forage weight) of estimating browse (Andrew *et al*.1979).

Seed production is generally the key to ensure the continued presence of annual plants. This raises a host of questions that are being partially addressed through Griffith University and the University of Queensland student projects, and may be answered through published information for similar plants. The major questions include:

- Are there any Land System composition effects?
- Are gutters, for instance, actually refuges for annual plant seed production?
- How much seed is produced?
- Are any of the annual species facultative perennials, able to seed more than once in a year?
- How long will the seed survive in the soil, especially under the extreme soil temperatures of the floodplains, and how deep do the extreme temperatures penetrate?
- What are the seed loss rates, e.g. how much seed is lost down the cracks of the floodplains?
- What species germinate after flooding compared with rainfall?

Safe utilisation levels and key periods of stress for annual species are also required to be able to the balance the feed budget equation.

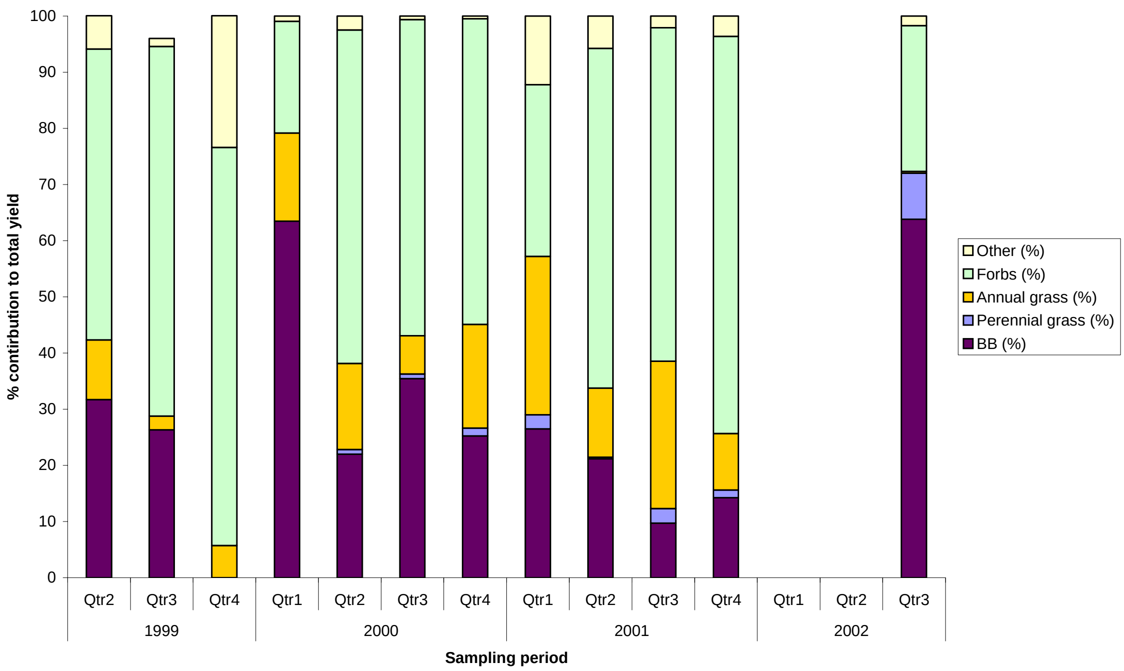
There are also a number of broader questions which have management implications. For instance:

- what is the real role of lignum? It appears to be a minor feed component on occasion, but is primarily a competitor for resources.
- How should these impacts be accounted for? Generally accepted methods such as estimating tree basal area are unsuitable for estimating lignum impacts.

It may also be important to understand the role lake Land Systems play in terms of both production and sustainability. Do they keep it ‘ticking over’ because they flood more frequently (e.g. from localised rains)? If so, are they more susceptible to grazing impacts than the channel Land Systems? In the same vein, are swamps actually unique as the World Wildlife Fund (WWF) maintain, or they simply a part of the C1 Land System as defined within WARLUS?

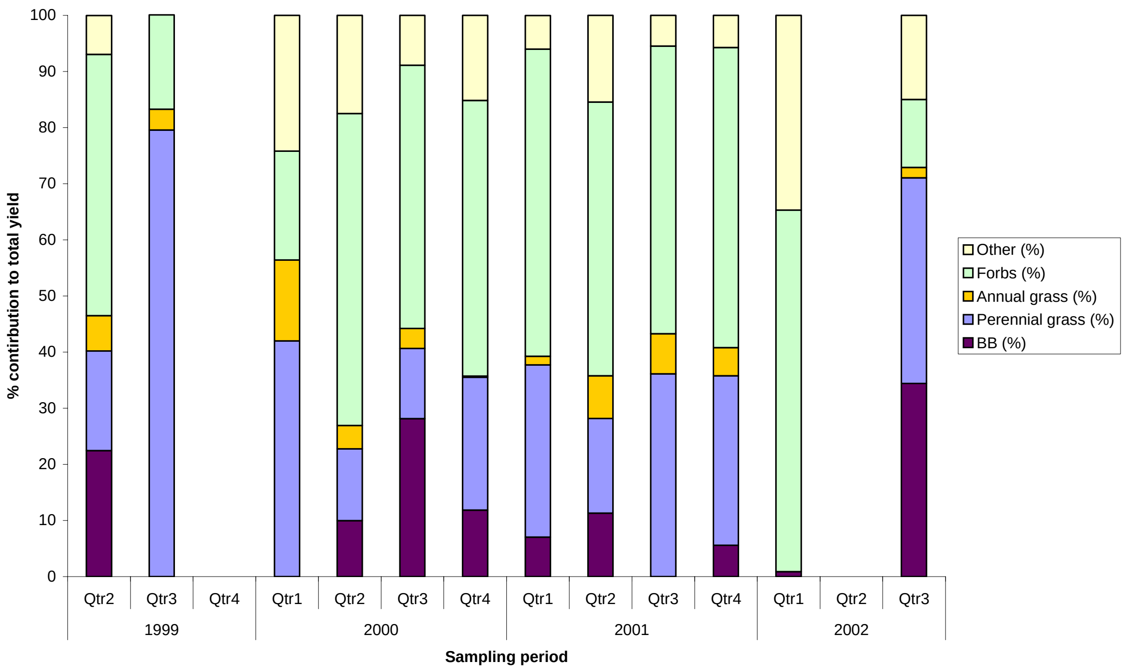
Whilst the majority of these questions are outside the scope of the project, industry consultation is needed to prioritise future studies which will impact on sustainable production.

a) C1B



100
90
80
70
60
50
40
30
20
10
0
% contribution to total yield
Qtr2
Qtr3
Qtr4
Qtr1
Qtr2
Qtr3
Qtr4
Qtr1
Qtr2
Qtr3
Qtr4
Qtr1
Qtr2
Qtr3
1999
2000
2001
2002
Sampling period
Other (%)
Forbs (%)
Annual grass (%)
Perennial grass (%)
BB (%)

b) C1L



100
90
80
70
60
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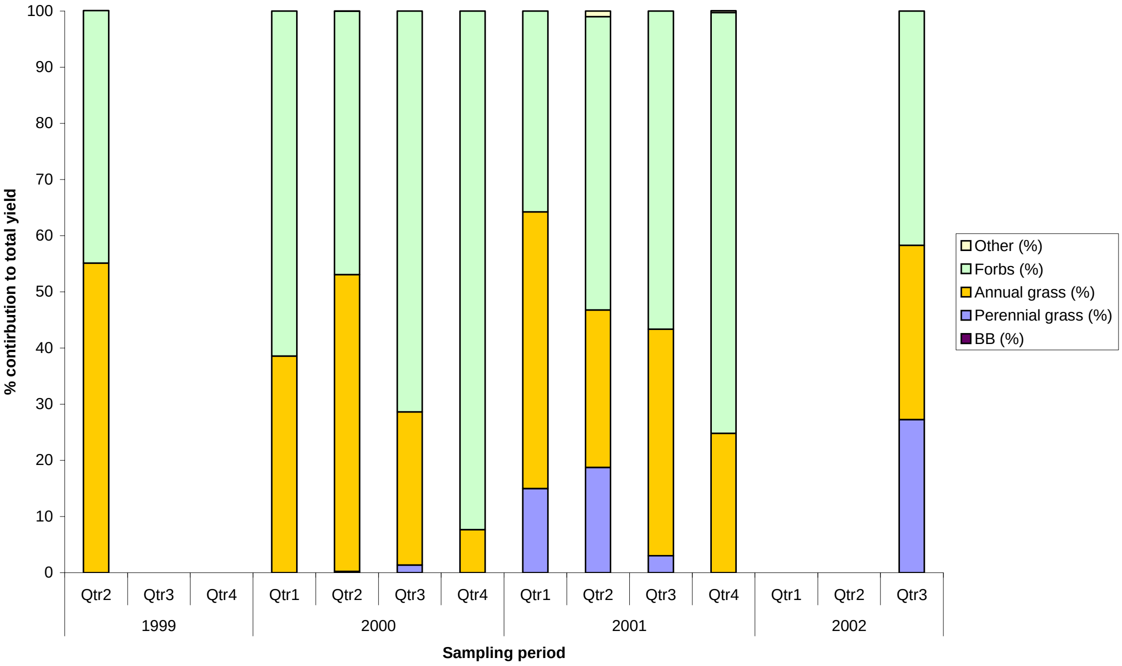
20
10
0
% contirbution to total yield
Qtr2
Qtr3
Qtr4
Qtr1
Qtr2
Qtr3
Qtr4
Qtr1
Qtr2
Qtr3
Qtr4
Qtr1
Qtr2
Qtr3
1999
2000
2001
2002
Sampling period
Other (%)
Forbs (%)
Annual grass (%)
Perennial grass (%)
BB (%)

c) C2



d) C3

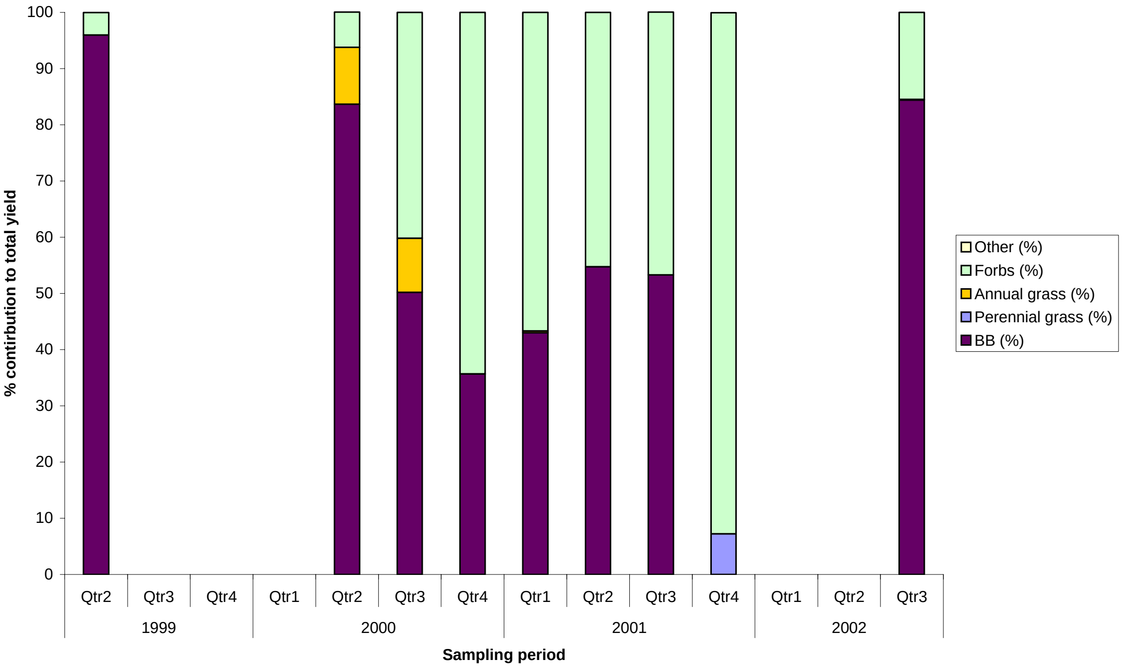
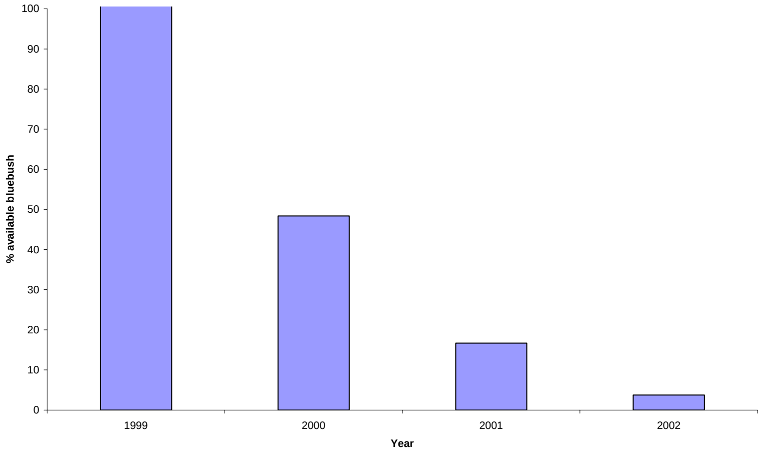
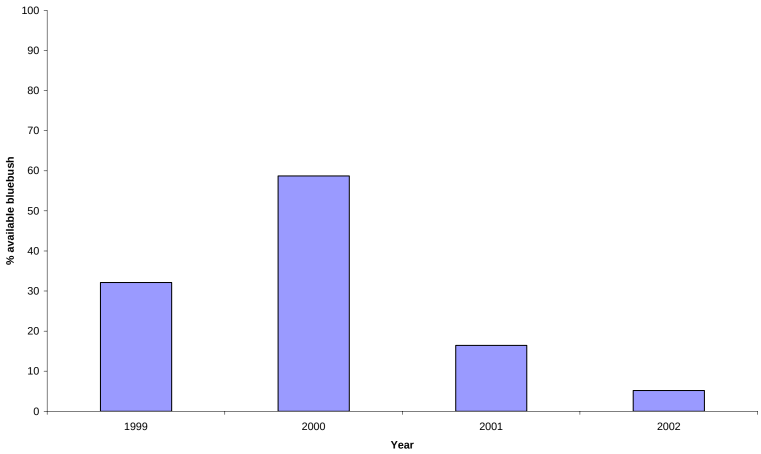


Figure 29. Plant group composition as a proportion of total yield across sites within a) C1B b) C1L c) C2 and d) C3 Land Systems.

a) Cooper Creek sites



b) Diamantina River sites



c) Georgina River sites

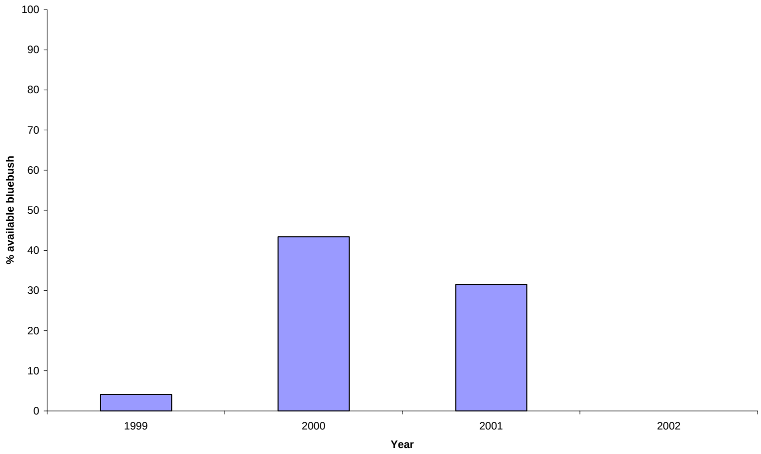


Figure 30. The proportion of bluebush yield estimated to be available (% of total bluebush yield).

Pasture nutrient levels

Sampling for pasture nutrient levels was undertaken according to the availability of plant material. Subsequently, not all plant groups had sufficient (or any) material available for sampling at each date. Budgetary constraints have precluded analysis of samples from October 2001 onwards, and restricted analysis to dry matter, organic matter, crude protein, metabolisable energy and IVDMD for the majority of samples. The information collected has been summarised by Land System and River system, and is averaged across both wet and dry periods. As such, the plant nutrient information should be treated as a reasonable guide to the comparative value of each plant group (samples include stem and recently senesced material). The values are likely to be at the lower, rather than the upper, end of the scale when compared with cattle diets, as cattle are better at seeking out a high quality diet based on individual plant species and components.

Crude protein (CP) levels of about 6% are required to maintain dry cattle liveweights under most circumstances. On average across Land Systems, annual grasses, perennial grasses and other plants were generally below maintenance requirements (Figure 31a), although annual grasses averaged around 9% protein in the C3 Land System. Other plants and perennial grasses were just adequate within sites on the Diamantina and Georgina, respectively, when averaged across River systems (Figure 31b). On average within plant groups, crude protein was highest in bluebush (8.2%), followed by forbs (7.9%), with other plants (5.3%), perennial grasses (4.9%) and annual grasses (4.5%) all very similar. Plant groups tended to have higher protein levels on the Georgina than on other River systems.

There were four main occasions (April, September and October 1999, November 2000) when crude protein levels were marginal or inadequate to maintain liveweights (Figure 35a). Levels were adequate at all other times, but could be expected to have declined considerably during the dry conditions since August 2001. During times of adequate protein, animal intake also needs to be adequate i.e. even when crude protein is high, cattle still need to source enough material within a reasonable walking distance to maintain or increase liveweight. As feed quantity declines, cattle need to walk further in order to maintain their intake of adequate quality material.

Digestibility (as measured by IVDMD) levels of 40-50% are typical for dry tropical pastures, based on whole plant analysis, whilst levels of 30-40% are generally regarded as poor. On average across Land Systems, annual grasses and forbs tended to be within the typical range, with the other plant groups within the poor range (Figure 32a). Differences across Land Systems were generally small, as were the differences across River systems (Figure 32b). On average within plant groups, digestibility was highest in forbs (45.5%) and annual grasses (43.2%), with bluebush (39.0%) and other plants (40.3%) similar and perennial grasses (36.7%) the least digestible.

There have been seven occasions when digestibility was within the poor range, with two occasions (May and June 1999) when levels have exceeded the typical range for tropical pastures (Figure 35b). In broad terms, digestibility has tended to decline over time following higher levels in early 1999.

Metabolisable energy (ME, MJ/kg) is calculated from IVDMD levels determined in the laboratory. Once IVDMD values decline below the 30-40% range, errors within the calculation of ME become compounded. Potentially, lower ME values recorded throughout the monitoring period could be under-estimated as a result.

In general, more than 6 MJ/kg is needed for weaners and other classes, whilst 5 MJ/kg of energy will maintain dry stock. On average across Land Systems, bluebush and perennial grasses have been marginal whilst annual grasses, forbs and other plants have exceed requirements (Figure 33a). Differences across Land Systems were generally small, although the C3 Land System had a higher annual grass ME. The Georgina tended to have slightly higher ME levels than other river systems (Figure 33b). On average within plant groups, ME was highest in annual grasses (5.7 MJ/kg) and forbs (5.6 MJ/kg), moderate in other plants (5.1 MJ/kg) and perennial grasses (4.9 MJ/kg) and lowest in bluebush (4.4 MJ/kg). ME steadily declined throughout the monitoring period, after starting in the 6 to 7 MJ/kg range in early 1999. The lowest ME recorded, on average, was below 4 MJ/kg in December 2000 (Figure 35d).

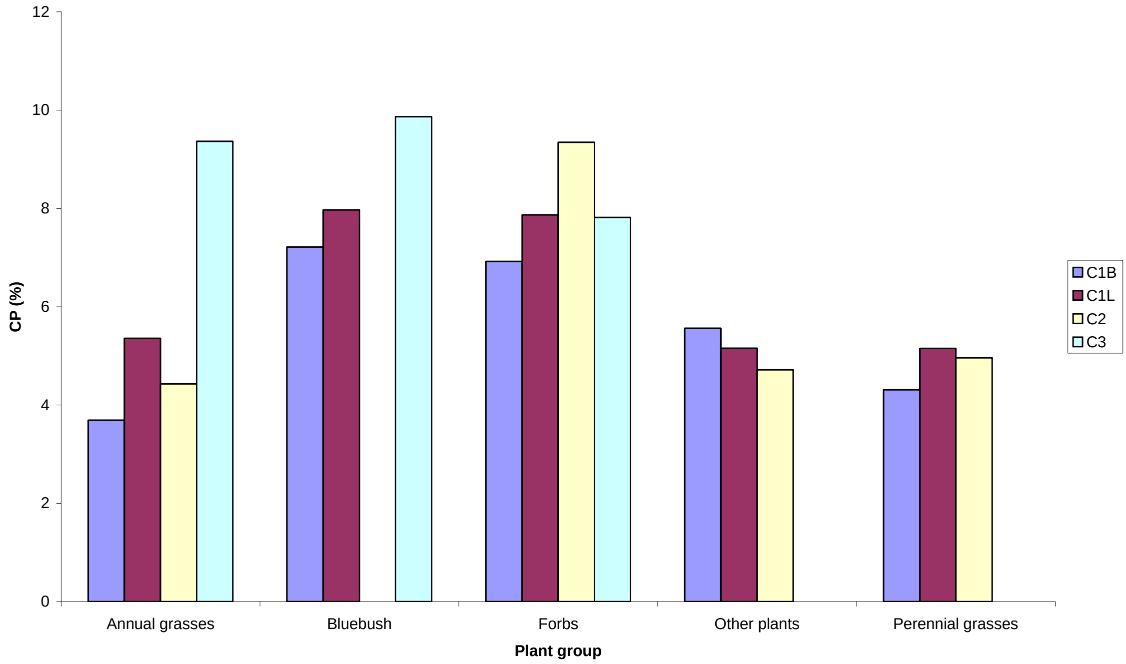
Pastures growing in clay soils generally have adequate Phosphorus (P) levels. According to McCosker and Winks (1994), marginal country has soils with levels of 7 to 8 mg/kg and plants with levels of 0.1 to 0.15%, whilst adequate levels are achieved when soils are greater than 8 mg/kg and plants greater than 0.20%. The clay soils of the floodplains have relatively high P levels, being greater than 8 mg/kg at all sites (Table 6).

On average across Land Systems, annual and perennial grasses and forbs have had in excess of 0.1 to 0.15% P, whilst bluebush fell within the marginal range (Figure 34a). The same was true across River systems. Phosphorus levels were higher on the Diamantina for annual grasses, forbs and other plants, but similar to the Cooper and Georgina for bluebush and to the Cooper for perennial grasses (Figure 34b). Perennial grass P levels have not been recorded for the Georgina due to insufficient material. On average within plant groups, P levels were highest in forbs (0.27%) and lowest in bluebush (0.12%) but similar between perennial (0.21%) and annual (0.19%) grasses and other plants (0.20%).

Phosphorus levels peaked (at nearly 0.35%) during early 2000 and reached their lowest levels in late 2001 (Figure 35d). It is quite likely that levels continued to decline into 2002.

In terms of animal production, as pasture quality and quantity decline and animals are required to graze the less fertile outside country pasture communitas (especially mulga and spinifex pastures), P levels may become inadequate for animal production.

a) Land Systems



b) Rivers

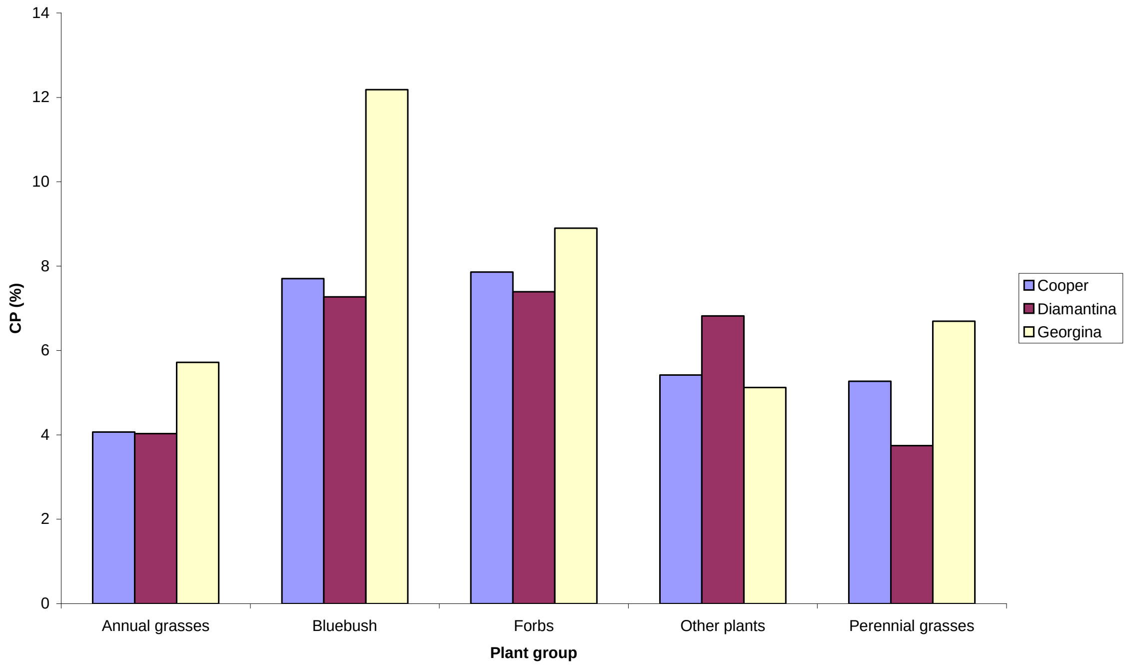
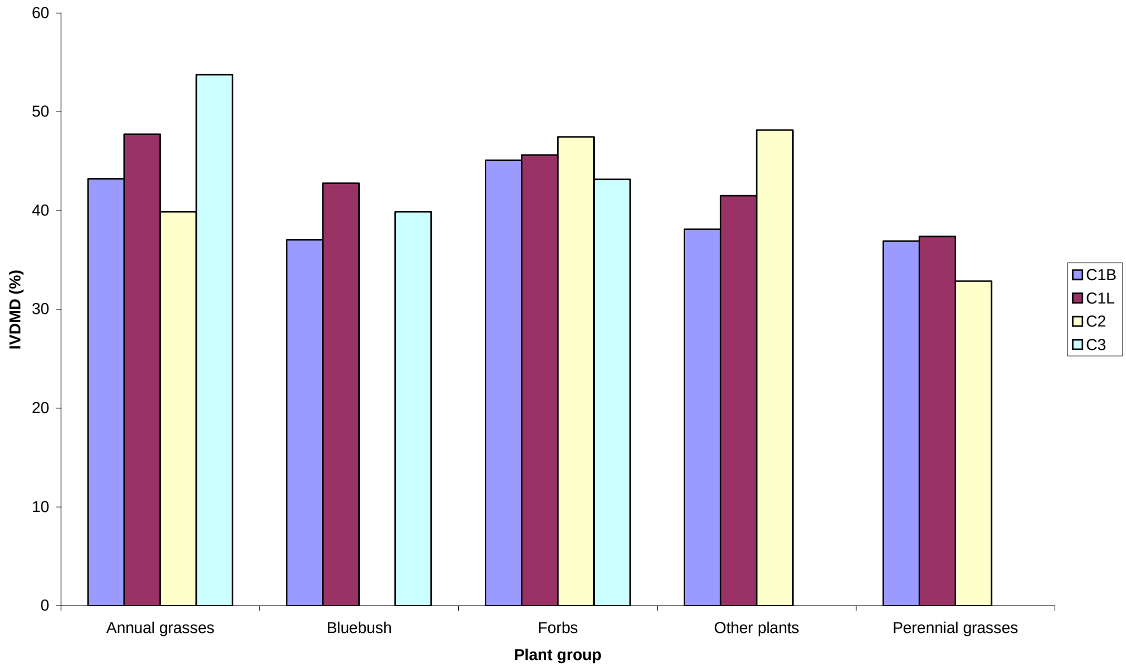


Figure 31. Average plant group crude protein (%) levels across a) Land Systems and b) River systems.

a) Land Systems



b) Rivers

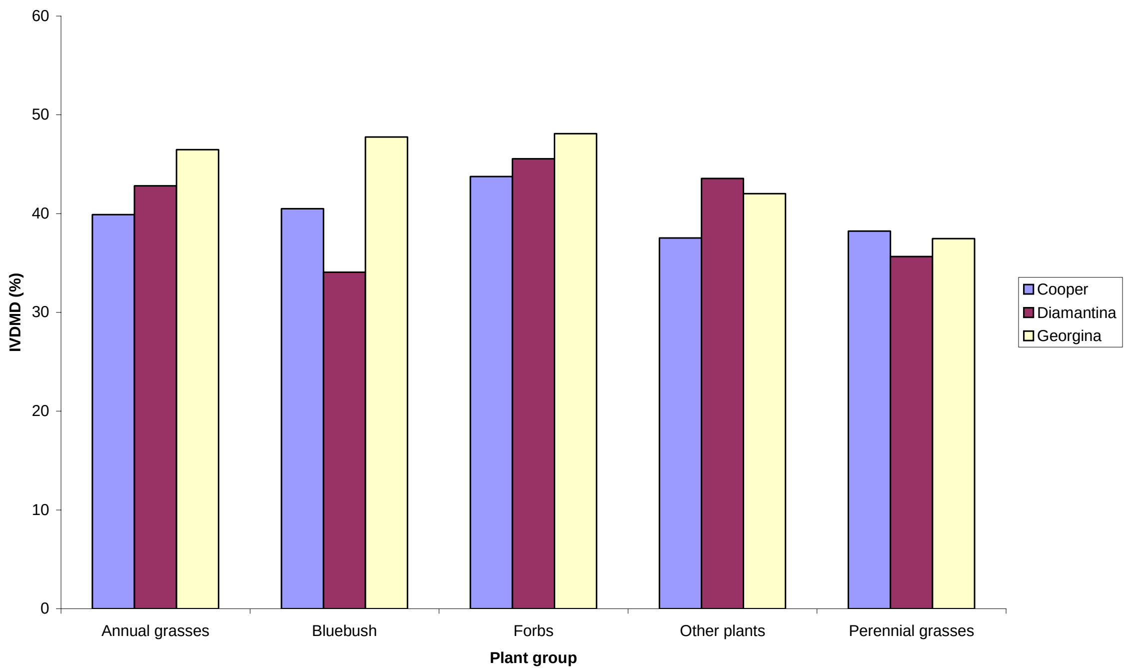
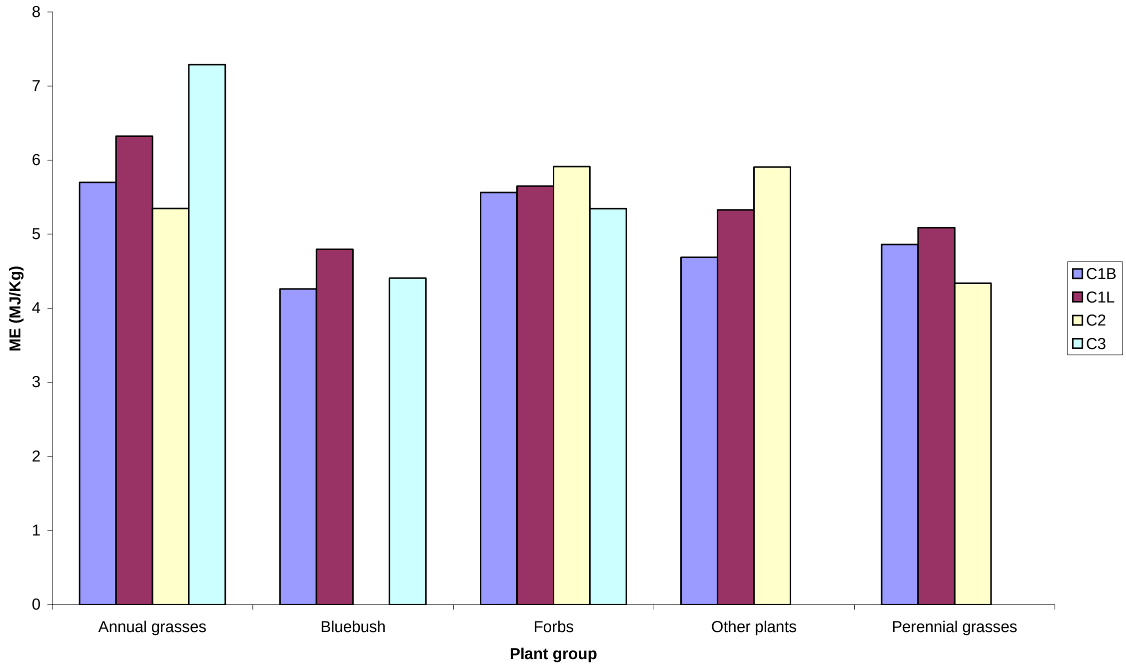


Figure 32. Average plant group IVDMD (invitro dry matter digestibility, %) levels across a) Land Systems and b) River systems.

a) Land Systems



b) Rivers

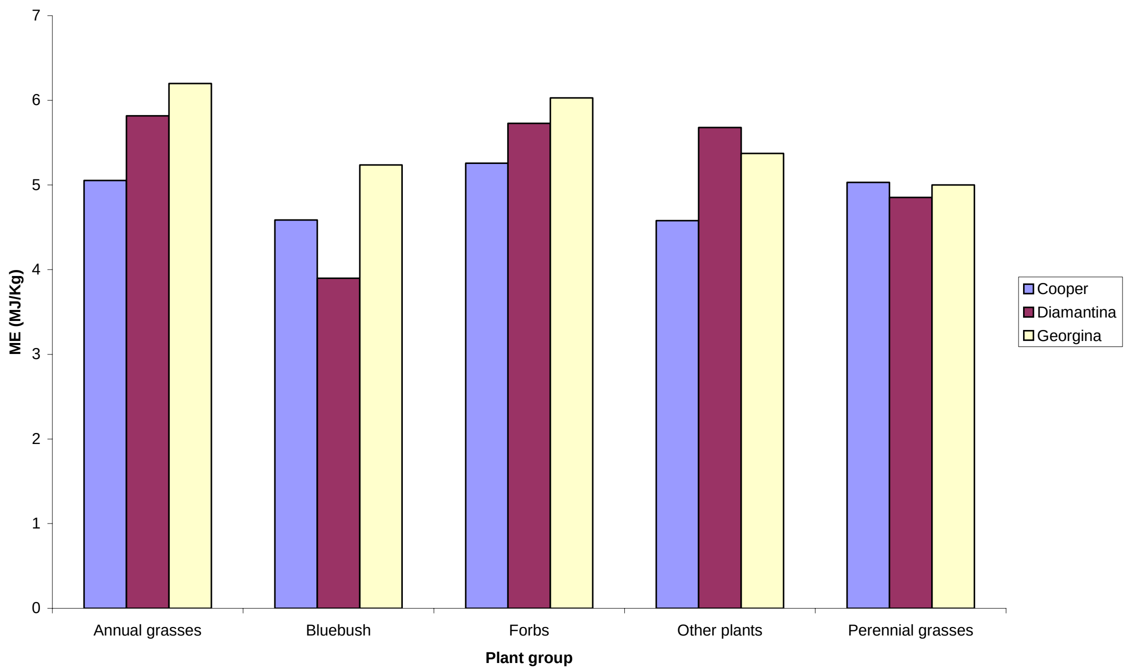
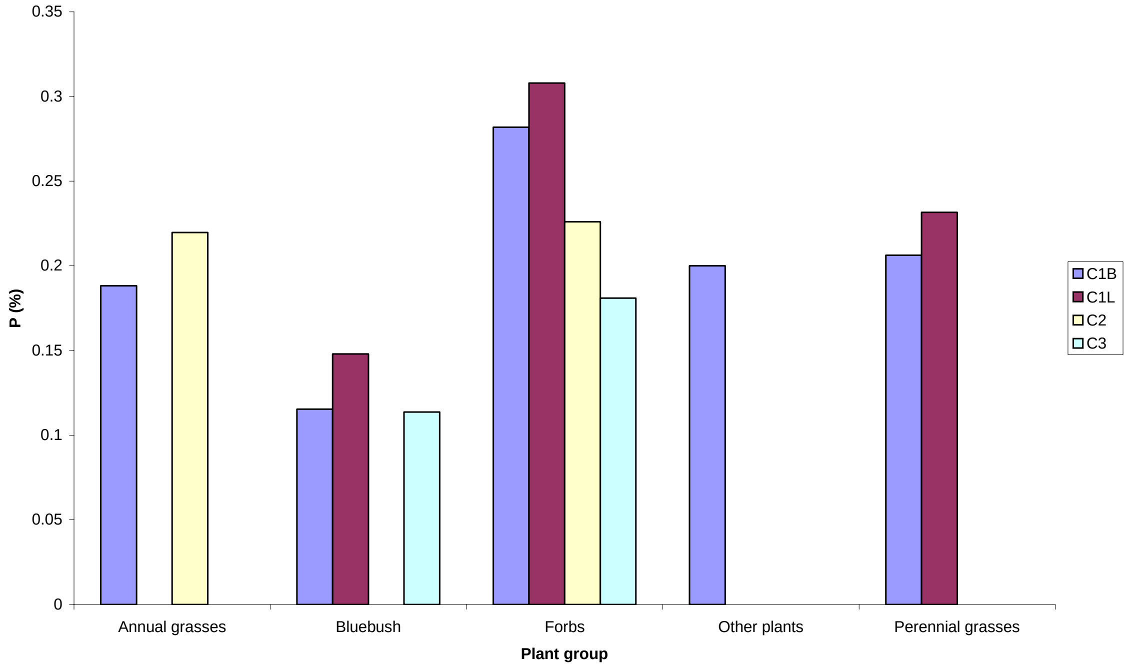


Figure 33. Average plant group Metabolisable Energy (MJ/kg) levels across a) Land Systems and b) River systems.

a) Land Systems



b) Rivers

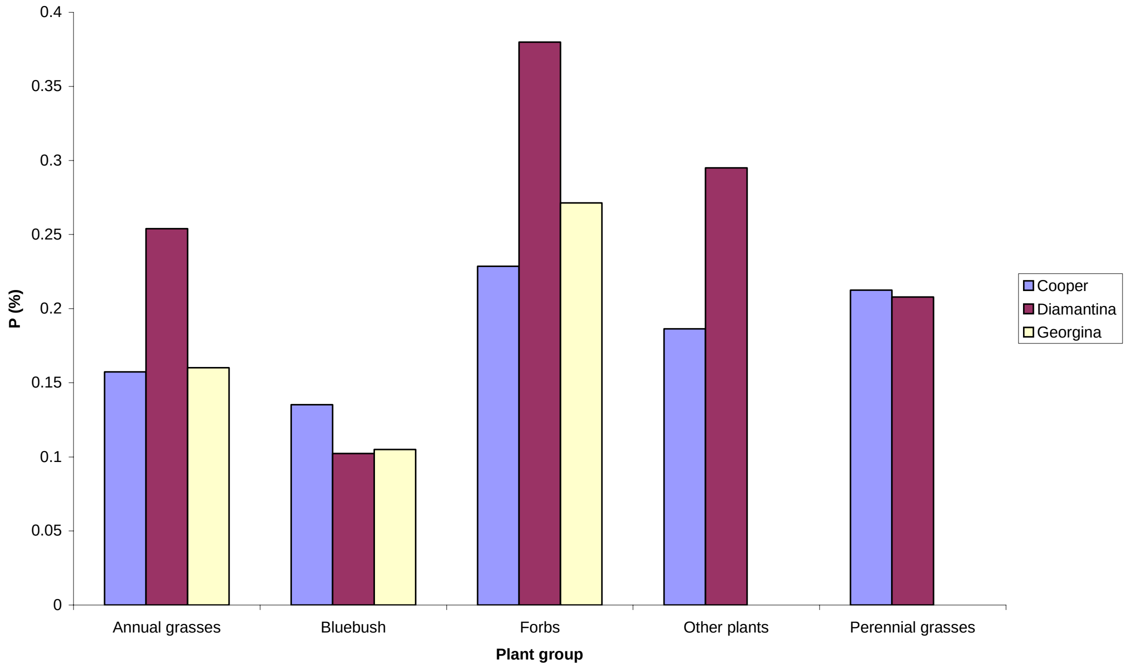
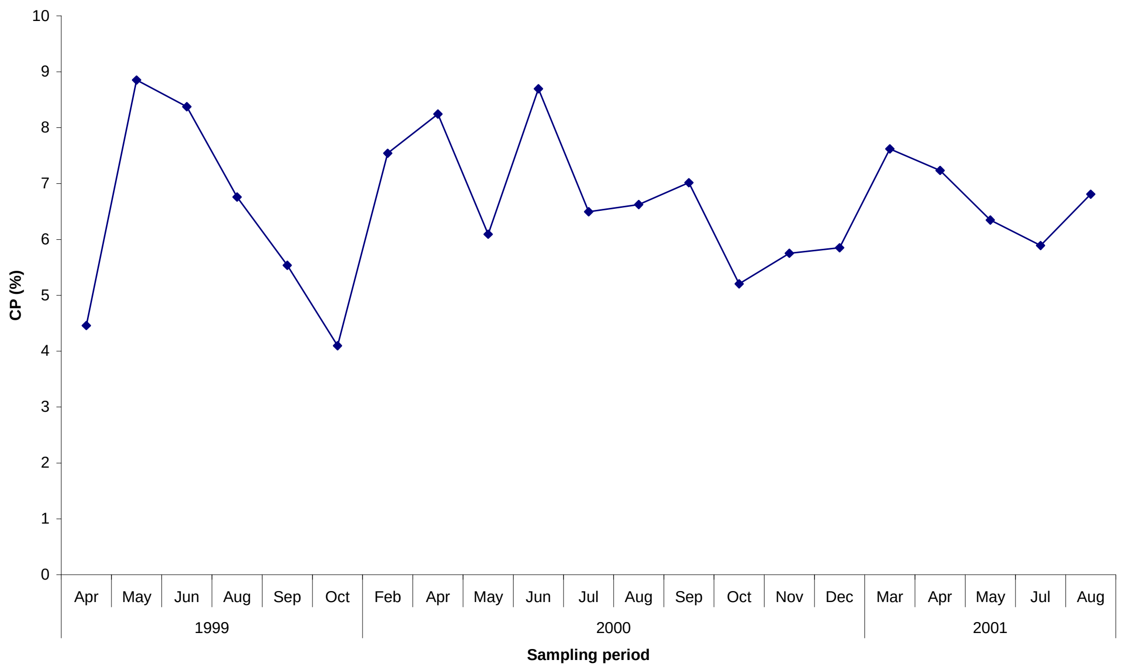
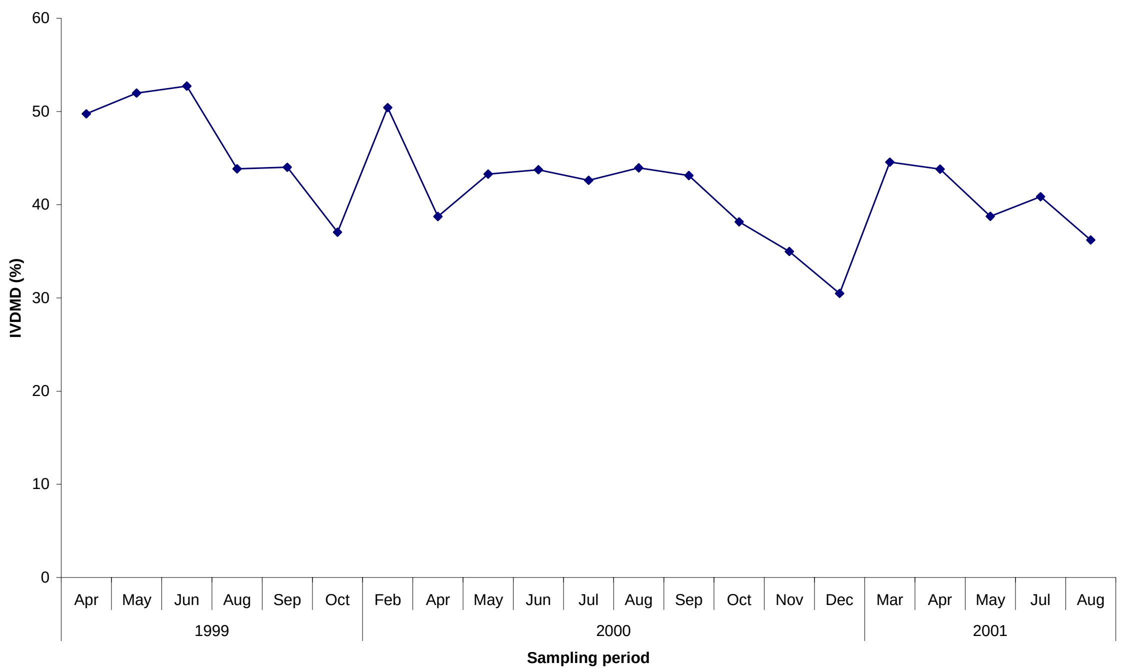


Figure 34. Average plant group Phosphorus (%) levels across a) Land Systems and b) River systems.

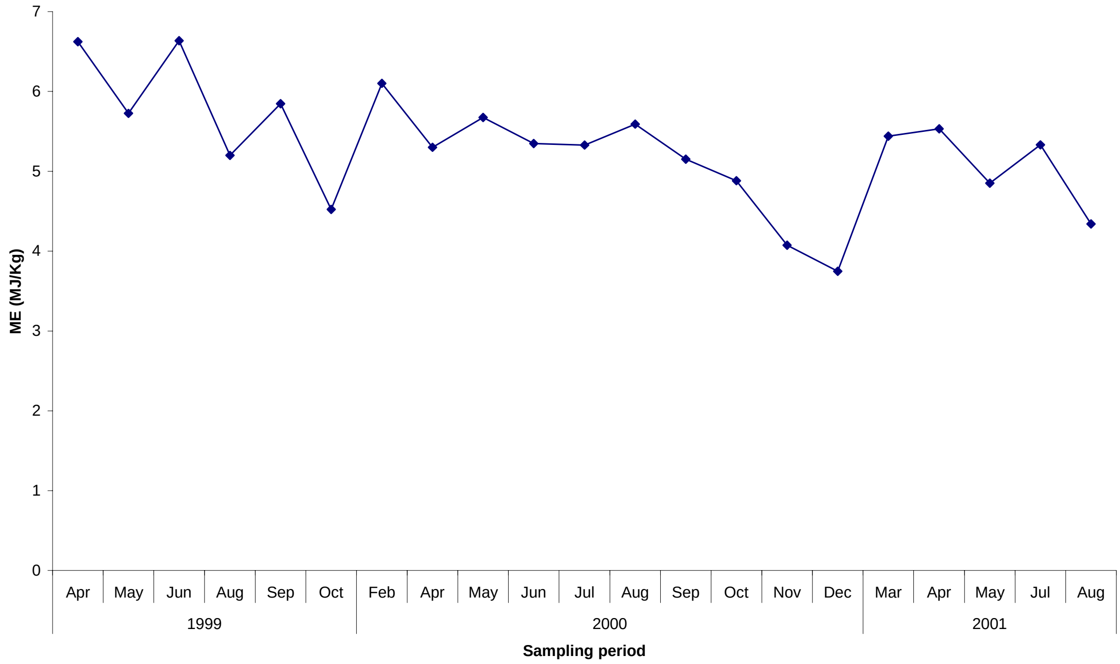
a) Crude protein



b) IVDMD



c) ME



d) Phosphorus

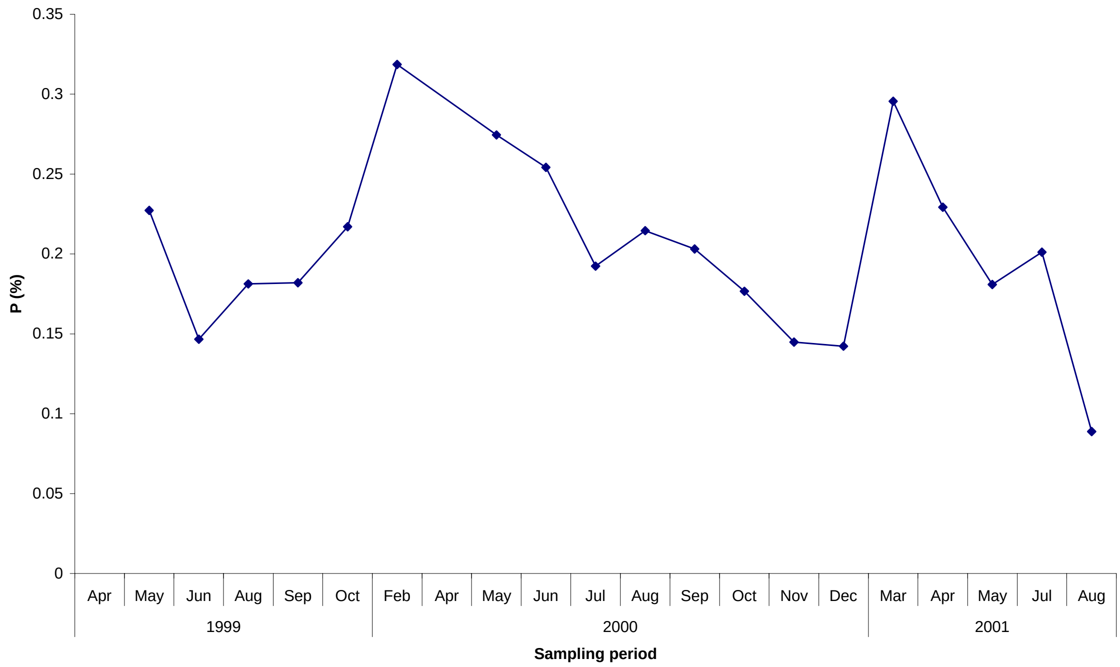


Figure 35. Trends in average a) crude protein (%) b) Metabolisable Energy (MJ/kg), c) Phosphorus (%)and d) IVDMD (invitro dry matter digestibility, %) levels over time

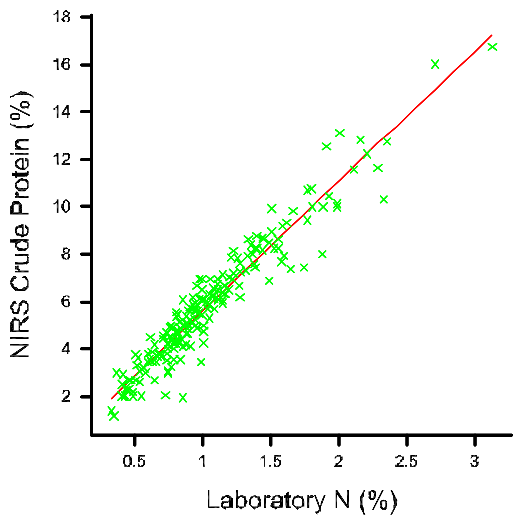
NIRS pasture analyses

Duplicates of the ground pasture samples for laboratory chemical analyses were sent to Dr David Coates for assessment using NIRS technology. This was additional to the original project objectives, and at no cost to the project. Dr Coates analysed the samples in exchange for the use of the project laboratory results to the benefit of both parties in exploring the potential of using NIRS to determine protein and digestibility for the plant species of the Channel Country floodplains.

There was a significant linear regression ($P<0.001$, $R^2=92.0$, $n=225$) between laboratory determined nitrogen levels and NIRS predicted crude protein (Figure 36a), indicating the potential for using NIRS in estimating nitrogen and crude protein levels for plants which grow on the Channel Country floodplains. Remaining samples held at the Davies Laboratory will be checked for consistency of results with standard chemical analyses undertaken by CSIRO and then included in the calibration set. This will provide a greater predictive range for the standard calibration equation.

However, at this stage, the predictive ability of digestibility using NIRS is inadequate for a laboratory-based technique. There was a significant linear regression ($P<0.001$, $R^2=64.4$, $n=225$) between laboratory determined IVDMD and NIRS predicted digestibility (Figure 36b), but only explaining 64% of the variability. At least 98% of the variance needs to be explained to provide a useful laboratory tool (David Coates, *pers*. *comm*.). One of the problems with the available dataset is an inconsistency in IVDMD techniques. The NIRS calibration curves have been developed on a pepsin cellulase technique, whilst the laboratory technique used was based on a rumen fluid technique. The two techniques provide different, and not always compatible, results. Once IVDMD predictions are possible, Metabolisable Energy can also be predicted. More work is required in this area.

a)



b)

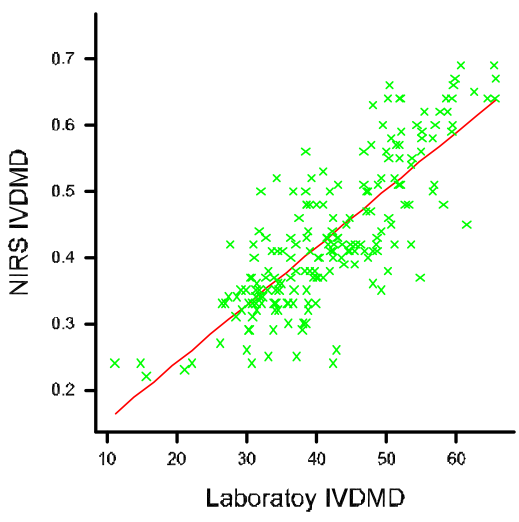


Figure 36. NIRS predictions of a) Crude Protein (%) and b) IVDMD from paired samples analysed using standard laboratory chemical techniques.

Vegetation changes under grazing

The overall decline in pasture yields (Figure 28a-q) during the extremely dry conditions over late 2001 and into 2002 (Table 5) appears to have been hastened, but not ultimately affected by, cattle grazing. Grazing may have increased the rate of detachment trough grazing and trampling of plant material, but with the same approximate end point reached over time. Theoretically, this can be presented as a slightly faster rate of pasture yield decline (Figure 37).

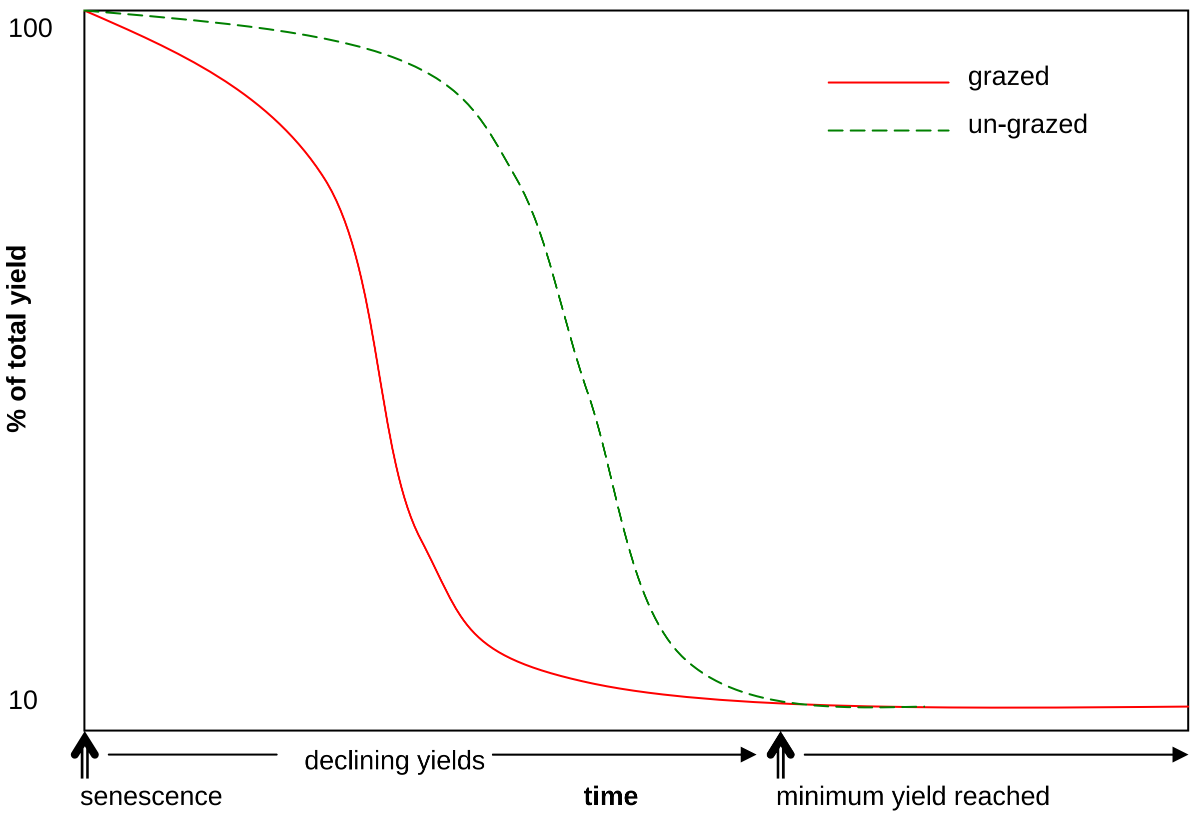


Figure 37. Theoretical impact of grazing on the rate of decline of pasture during extended dry periods.

There were few differences between the frequency of the major plants present in August 2002 under grazed or exclosed conditions (Table 7). Only cow vine was present more frequently under exclosed (34%) than under grazed (21%) conditions (P =0.009). Similar results were found in a preliminary soil seed bank survey conducted during favourable conditions (Rieck 2000). The frequency of litter was high (81% and 73% under grazed and exclosed conditions), reflecting the dry conditions and the long duration of plant detachment prior to recording.

Pasture yields were very low within C1L and C2 Land Systems, but maintained by standing remnant bluebush material in the C1B and C3 Land Systems in August 2002 (Figure 38a). Across Land Systems, C1B, C1L and C2 yields tended to be higher under exclosed than grazed conditions, but C3 yields were considerably lower under exclosed conditions, predominantly based on lower bluebush yields (Figure 39a). There was a significant effect of River (P=0.021) and Land System (P=0.004) on bluebush yield, but no grazing effect. When examined across River systems the average yield of grazed sites was higher than exclosed sites on the Cooper, whilst the reverse was true for the Diamantina (Figure 38b). Yields on the Georgina were equivalent under both grazed and exclosed conditions. Examples of the decline in pasture yields, and the lack of differences between grazed and exclosed conditions, is presented pictorially for Site 13 (a C2 Site on the Diamantina River) in Figure 39. The theoretical difference in the rate of decline under grazed compared with exclosed conditions can be seen visually from May 2001 onwards, when the yields within the grazed photographic sequence start to appear lower than in the exclosed sequence. The yields for Site 13 were estimated at 52 and 110 kg/ha in August 2002 under grazed and exclosed conditions respectively. These minimum yields represent 2% and 4% of the peak ungrazed yield of 2700 kg/ha and suggest any grazing impacts on yield are minor.

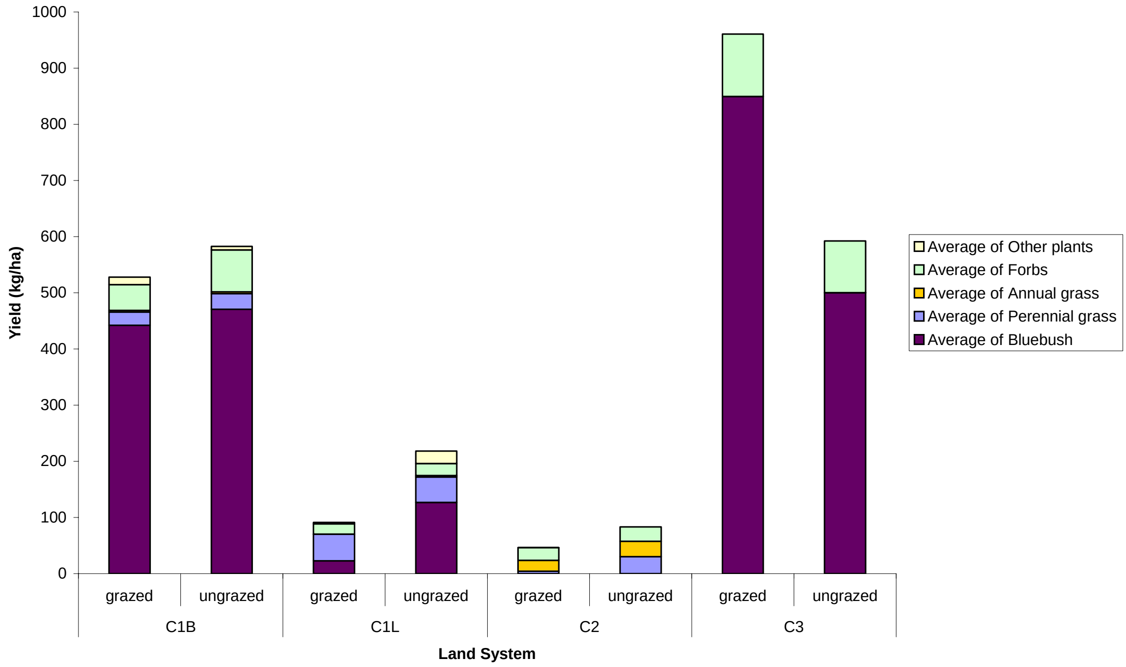
Monitoring is now recommended as pasture recovers following the current drought conditions to determine if there are detectable differences in either plant species composition or pasture yields. It would also be useful to monitor both a wet summer and a wet winter period. A number of Q-Graze monitoring sites were established on the floodplains in the 1990s. It may be worthwhile to relocate and monitor these through the next flood event. This activity would potentially fit into the national rangelands audit, helping to meet Queensland's commitment to the Federal government, and may also provide further data for the development of EMS schemes.

Table 7. Plant species and group frequency in August 2002 following continued grazing or exclosure (ungrazed) since 1999, averaged across all Land and River systems.

Plant species or group		Frequency (% occurrence)	
Common name	Botanical name	grazed	ungrazed
	Grasses		
Rat's tail couch	*Sporobolus mitchellii*	23.8	19.2
Native sorghum/channel millet	*Echinochloa turneriana*	12.2	13.5
Other grass		14.1	19.8
	Forbs		
Tall sedge	*Cyperus exaltatus*	11.0	8.0
Spiny flat sedge	*Cyperus gymnocaulos*	6.9	9.8
Tall nutheads	*Epaltes cunninghamii*	11.2	11.6
Nardoo	*Marsilea drummondii*	52.7	56.3
Common joyweed	*Alternanthera nodiflora*	28.0	25.5
Native cucumbers	*Cucumis* & *Mukia* spp.	0.4	3.9
Cow vine	*Ipomoea lonchophylla*	21.2*	34.1*
Silky goodenia	*Goodenia fascicularis*	43.3	26.7
Goodenia	*Goodenia strangfordii*	0.2	2.2
Pigweed	*Portulaca oleracea*	3.5	4.1
Purple sesbania	*Sesbania brachycarpa*	4.1	4.7
Other forbs		29.7	35.5
	Shrubs		
Queensland bluebush	*Chenopodium auricomum*	15.5	14.9
Lignum	*Muehlenbeckia cunninghamii*	2.5	5.1
litter		80.6	72.5

* significant grazing effect (P=0.009)

a)



b)

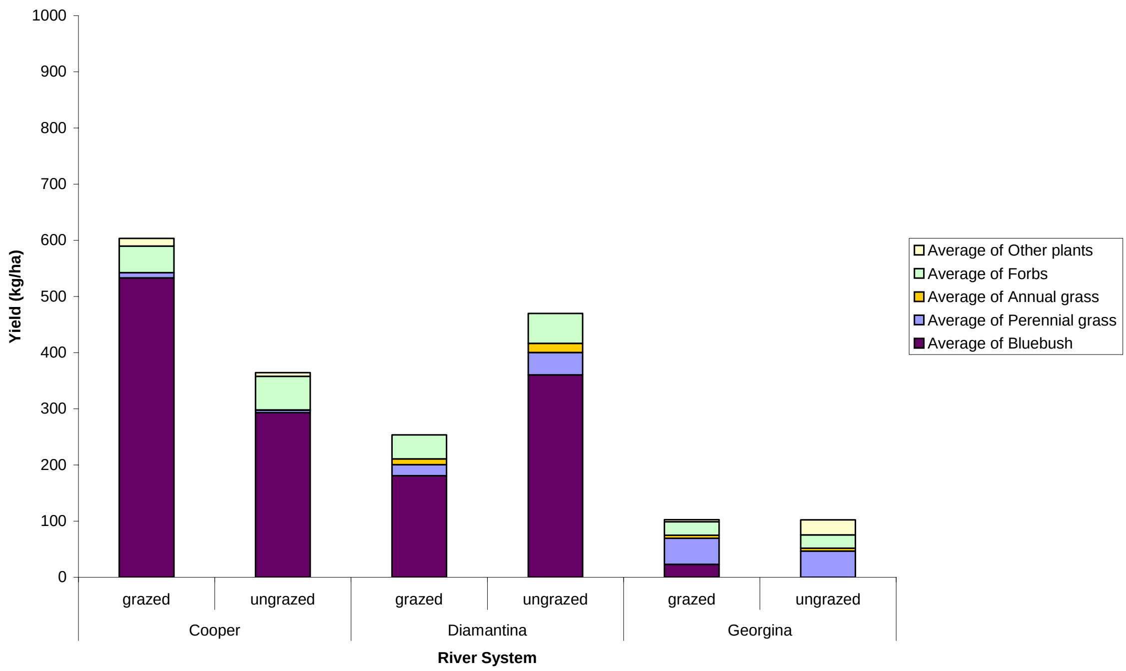


Figure 38. Dry matter yields (kg/ha) of major plant groups in August 2002 following continued grazing or exclosure (ungrazed) since 1999 across a) Land Systems and b) River systems.

Grazed	Exclosed	Date
		2/6/00
		5/5/00
		29/6/00
		23/8/00

Grazed	Exclosed	Date
		27/2/01
		13/5/01
		18/7/01
		8/12/01

Grazed Exclosed Date

17/3/02

1/5/02

1/8/02

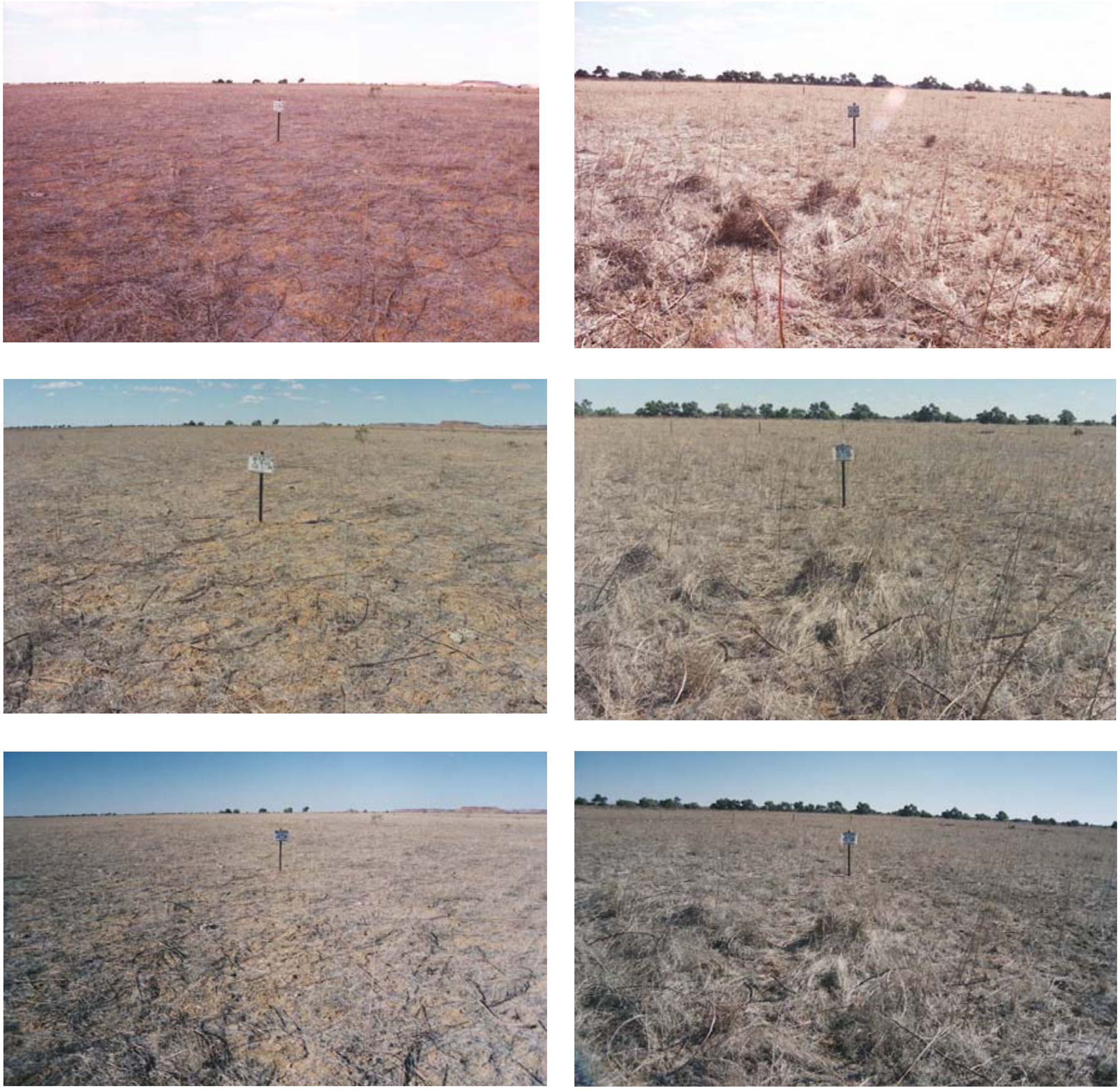


Figure 39. Photographic trends in pasture yield and quality on the Diamantina, under grazing or exclosure.

Preliminary modelling to integrate data and predict pasture growth

Exploration of soil and pasture relationships

There was a significant (P<0.001) correlation between soil moisture at all incremental depths (Table 7). This correlation tended to lessen as the distance between depths increased (e.g. the correlation between 0-10 cm depth and 90-100 cm was less than at 10-20 cm depth, albeit still highly significant). There was a significant linear regression (P<0.001, R^2=67.7, n=131) between each depth and the average of the full soil moisture profile (Figure 40, Figure 41), indicating some possibility of estimating profile moisture content from surface, or other depths. This could have practical implications for future sampling efforts, or for potential monitoring systems. It does not, however, discount the fact that moistures at depth at individual times may not be reflected by surface moisture contents.

There were a number of highly significant and significant correlations between a large range of factors which have the potential to impact on cattle productivity, or which may be important within pasture modelling (Table 9). The highly significant correlations are discussed below.

IVDMD was positively correlated with P, crude protein and ME (ME is calculated from IVDMD) and negatively correlated with dead cover. P was positively correlated with ME and negatively correlated with dead cover. Crude protein was negatively correlated with dead cover and quality rank. The dead cover correlations probably reflect declining pasture conditions, as the quantity of dead material accumulates and increases during dry periods. The negative correlation with quality rank reflects the scale used (where 1 is the highest quality, with the highest cattle growth rates and 5 is the worst) and suggests the estimation technique used may have application in its intended role of potentially estimating cattle growth rates.

Green cover was strongly positively correlated with green yield, reflecting the derivation of green yield from green cover, and with soil moisture, reflecting the need for adequate soil moisture to maintain pasture greenness. Dead cover was negatively correlated with green yield and soil moisture and positively correlated with quality rank, reflecting the increase in the proportion of dead and senesced material as the soil dries. Soil moisture was poorly correlated with any of the measured plant group yields, and poorly correlated with total yield. This lack of a simple relationship between soil moisture and pasture yield indicates the need to model pasture growth.

Bluebush yield was positively correlated with estimated useful bluebush yield. The yield of forbs was positively correlated with total, estimated total useful and green yield, possibly reflecting the large component forbs have comprised of the total yield. Perennial grass yield was positively correlated with dead yield, an association which is difficult to explain. Total useful yield was positively correlated with total yield and green yield, reflecting the use of each parameter in the visual estimation of total useful yield. Green yield was negatively correlated with quality rank, reflecting the use of apparent greenness in the visual estimation of quality rank. Green yield was positively correlated with the average of soil moisture throughout the profile, reflecting the need for adequate soil moisture to maintain pasture growth and greenness.

Pasture growth phase was positively correlated with the estimated quality rank, reflecting the use of growth phase to assist in visually estimating the quality rank score.

Quality rank was negatively correlated with the average of soil moisture throughout the profile, possibly because of the correlation between green yield and soil moisture, and the use of greenness in estimating quality rank.

Table 8. Correlation matrix for soil moisture (%) at all sampled depths and on average throughput the full profile (minimum n = 141, P<0.05 for all correlations).

Soil depth (cm)	0 to 10	10 to 20	20 to 30	30 to 40	40 to 50	50 to 60	60 to 70	70 to 80	80 to 90	90 to 100	0 to 100
0 to 10	1.000										
10 to 20	0.942	1.000									
20 to 30	0.907	0.984	1.000								
30 to 40	0.857	0.941	0.976	1.000							
40 to 50	0.774	0.858	0.901	0.958	1.000						
50 to 60	0.674	0.743	0.786	0.864	0.953	1.000					
60 to 70	0.568	0.620	0.661	0.744	0.862	0.962	1.000				
70 to 80	0.514	0.547	0.582	0.665	0.786	0.905	0.974	1.000			
80 to 90	0.484	0.503	0.532	0.614	0.725	0.851	0.925	0.969	1.000		
90 to 100	0.460	0.465	0.491	0.570	0.673	0.794	0.865	0.917	0.978	1.000	
0 to 100	0.841	0.888	0.910	0.943	0.963	0.951	0.899	0.856	0.821	0.779	1.000

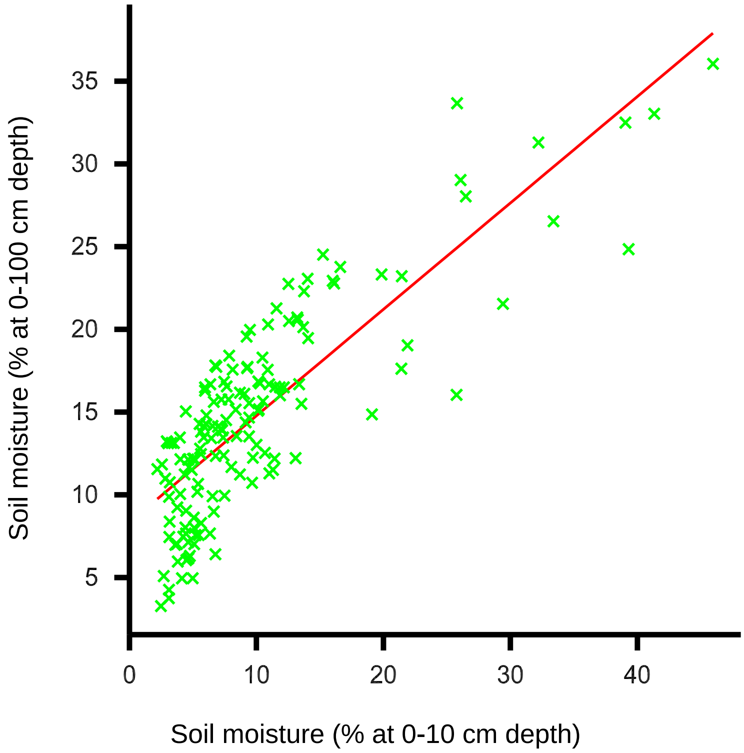


Figure 40. The relationship between gravimetric soil moisture (%) at 0-10 cm and the average throughout the profile.

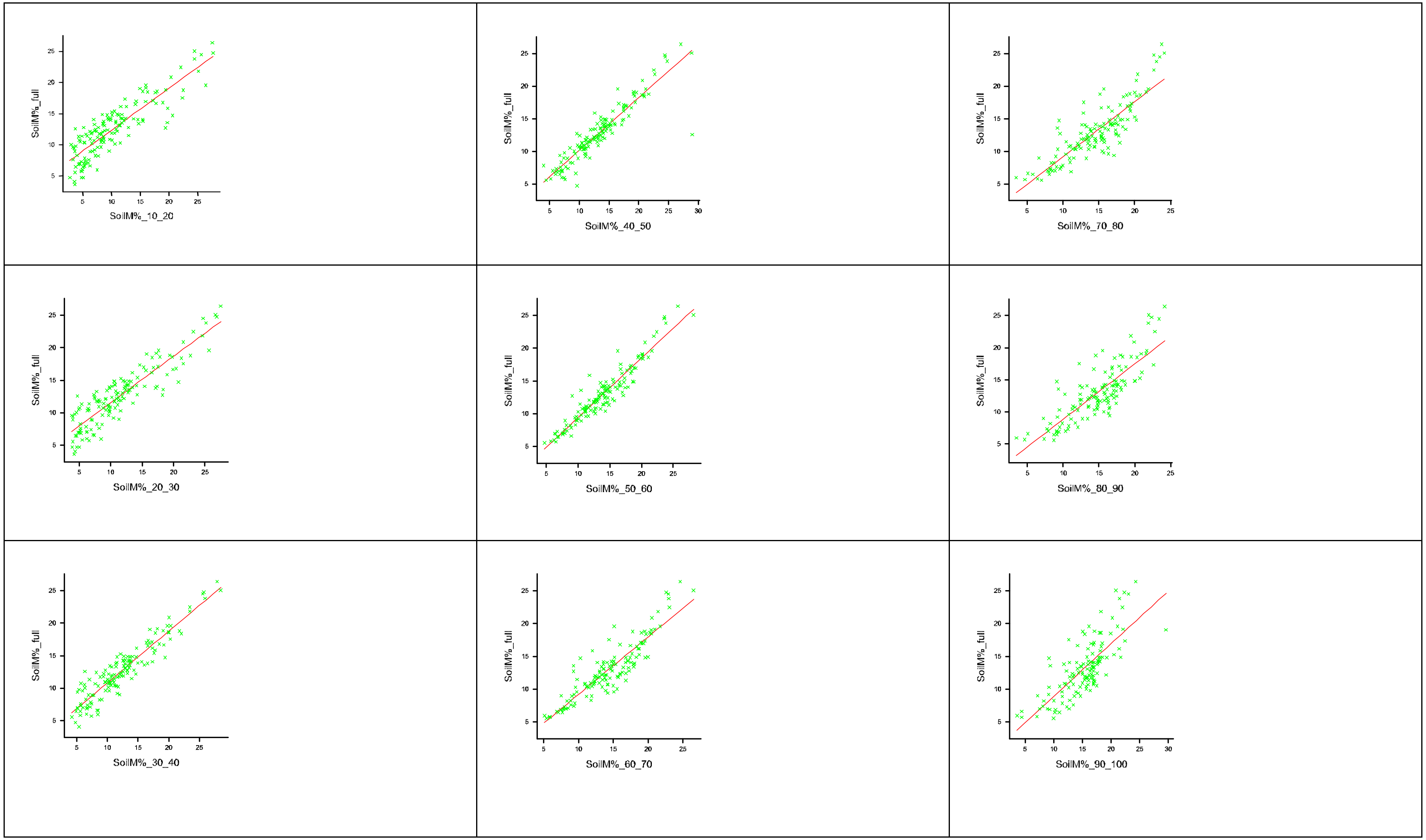


Figure 41. The relationship between gravimetric soil moisture (%) at incremental depths and the average throughout the profile.

Table 9. Correlation matrix for the major potential influences on cattle growth rates (average IVDMD, P, Crude Protein and ME; green, dead and litter cover, annual grass, bluebush, estimated useable bluebush and forbs yield, growth phase, total, perennial grass, total useable, other plants, dead and green yield, quality rank and average soil moisture, minimum n = 40). The correlations of main importance (highly significant, ** P<0.0001) are highlighted.

Parameter	%IVDMD	%P	%Protein	ME	G cover	D cover	L cover	AG Yield	BB Yield	EU BB yield	F Yield	Phase	T Yield	PG Yield	TU yield	O Yield	D yield	G yield	QR	Soil M
%IVDMD	1.000																			
%P	0.656**	1.000																		
%Protein	0.688**	0.473	1.000																	
ME	0.629**	0.699**	0.422*	1.000																
G cover	0.069	0.177	0.326*	-0.033	1.000															
D cover	-0.509**	-0.561**	-0.503**	-0.405*	-0.466*	1.000														
L cover	0.127	0.166	0.269	0.219	-0.102	0.098	1.000													
AG Yield	0.082	0.208	-0.452*	0.175	-0.202	0.082	-0.029	1.000												
BB Yield	-0.114	0.093	-0.075	-0.004	0.073	-0.184	-0.366*	0.197	1.000											
EU BB yield	-0.078	0.096	0.030	0.014	0.182	-0.385*	-0.355*	-0.063	0.681**	1.000										
F Yield	-0.088	-0.273	0.132	-0.235	0.488*	0.204	0.018	-0.370*	-0.224	-0.192	1.000									
Phase	-0.245	-0.345	-0.459*	-0.257	-0.467*	0.671*	0.113	0.141	-0.277	-0.304	0.038	1.000								
O Yield	-0.259	-0.104	-0.229	-0.215	0.196	0.103	-0.024	-0.134	-0.179	0.061	0.142	-0.030	1.000							
PG Yield	-0.110	0.142	-0.256	0.049	-0.133	-0.079	0.049	0.432*	0.080	0.018	-0.318*	0.080	-0.108	1.000						
TU yield	-0.089	-0.185	-0.079	-0.184	0.481*	0.195	-0.056	0.055	-0.038	-0.057	0.890**	0.055	0.147	-0.111	1.000					
T Yield	-0.118	-0.155	-0.112	-0.179	0.457*	0.176	-0.144	0.145	0.260	0.055	0.789**	-0.010	0.056	-0.075	0.947**	1.000				
D yield	-0.151	0.035	-0.315*	0.075	-0.078	0.138	0.189	0.424*	-0.016	-0.069	-0.173	0.224	0.053	0.646**	0.023	0.027	1.000			
G yield	0.150	0.226	0.275	0.036	0.855**	-0.538**	-0.248	-0.088	0.338*	0.339*	0.523**	-0.484*	0.132	-0.044	0.601**	0.654**	-0.082	1.000		
QR	-0.462*	-0.331	-0.628**	-0.293	-0.550**	0.656**	0.266	0.261	-0.259	-0.422*	-0.210	0.647**	0.104	0.185	-0.174	-0.201	0.417*	-0.649**	1.000	
Soil M	0.152	0.258	0.355*	0.212	0.595**	-0.558**	-0.127	-0.153	0.235	0.450*	0.103	-0.442*	0.099	-0.212	0.119	0.133	-0.091	0.552**	-0.508**	1.000

Key:
%IVDMD = plant digestibility (%)
%P = plant Phosphorus (%)
%Protein = plant protein (%)
ME = plant metabolisable energy (Mj/kg)
G cover = green cover (%)
D cover = dead cover (%)
L cover = litter cover (%)
AG yield – annual grass yield (kg/ha)
BB yield = Queensland bluebush yield (kg/ha)
EU BB yield = estimated useful Queensland bluebush yield (estimated kg/ha)
F yield = forbs (dicotyledonous plants) yield (kg/ha)
Phase = growth phase (1 to 4)
T yield = total yield (kg/ha, the sum of AG, BB, F, PG and O yields)
TU yield = total useful yield (estimated kg/ha)
O yield = other (plants not fitting within the previous categories) yield (kg/ha)
D yield = dead yield (calculated from D cover, kg/ha)
G yield = green yield (calculated from G cover, kg/ha)
QR = quality rank (estimated on a scale of 1 to 5)
Soil M = average soil moisture through the full profile (%)

Preliminary GRASP results

Rainfall/flood records

Specific rainfall and flood records were available from 1999 to June 2000. It was possible to update daily rainfall records from the Bureau of Meteorology Silo website until midway through 2001, as the site chosen is near an official recording station. It was assumed that floods receded from the site once gauging station data fell below 3.5m (0.5m below the moderate flood level). The soil water was reset to a full profile after each flood. It did not appear necessary to adjust pasture biomass to account for possible additional death or detachment due to flooding. However detachment rates were set at a high level over summer that may account for potential biomass losses as a result of flooding. Since June 2000, when gauging station data was unavailable, date of flood recession was estimated based on general flood records provided for the Channel Country (Table 5). The flooding experienced in December 2000/January 2001 was inferred from the soil moisture profiles. Model outputs are presented in Figures 42a to 46a.

Soil water

The only “unusual” change required to default parameters was to impose additional restrictions to water extraction below 50 cm than is usually the case for perennial grass pastures. There is some indication that wilting points may be lower under high annual pasture biomass in 2001/2. The calibration of field capacity/saturation was problematic, but reasonable estimates were obtained based on “back calculation” from observation periods.

“Outlier” of low observed biomass and cover on 25/5/2000

The only major outlier prior to 2001/2 was for cover and biomass on 25/5/2000. Inspection of the quadrat data indicates that in the harvests before and after May 2000, three of the nine quadrats contained bluebush. Bluebush in each of these quadrats had high biomass and, at this time, bluebush was the dominant component of the site. However for the harvest of 25/5/2000 only one quadrat contained bluebush. Hence, the outlier at this time would almost certainly appear to be due to site variability. This high variability had been observed during the field data collections and possible solutions discussed. Both the modelling and direct observations suggest the best way of reducing the variability would be to non-destructively sample bluebush each harvest for the entire exclosure. Line transects for estimating bluebush yields and growth were established in late 2001 to overcome this potential problem, and minimum bluebush yields visually estimated for each site to allow for back-transformations of existing data.

“Outliers” of high observed biomass and cover from 21/10/01 onwards

The model closely simulated observed total biomass (Figure 22a), green biomass (Figure 43a), green cover (Figure 44a) and soil water (Figures 45a, 46a and 47a) apart from the 2001/2 summer. Rainfall from the NR&M rainfall surfaces was inadequate to provide reasonable simulations for the 2001/2 summer period (e.g. see Figure 42). This could mean that:

1) flooding occurred (although not indicated in general observations, Table 5)

2) much higher rainfall was received than indicated on NR&M surfaces; and/or

3) parameters the first two years (with a high bluebush component) were inadequate for modelling the last year of data (with a high annual component)

The latter may be especially pertinent, with a high mortality of bluebush observed in the field following the 2001 flood event. The mortality may be linked with high summer temperatures and observed clear (compared with the usually turbid) floodwaters.

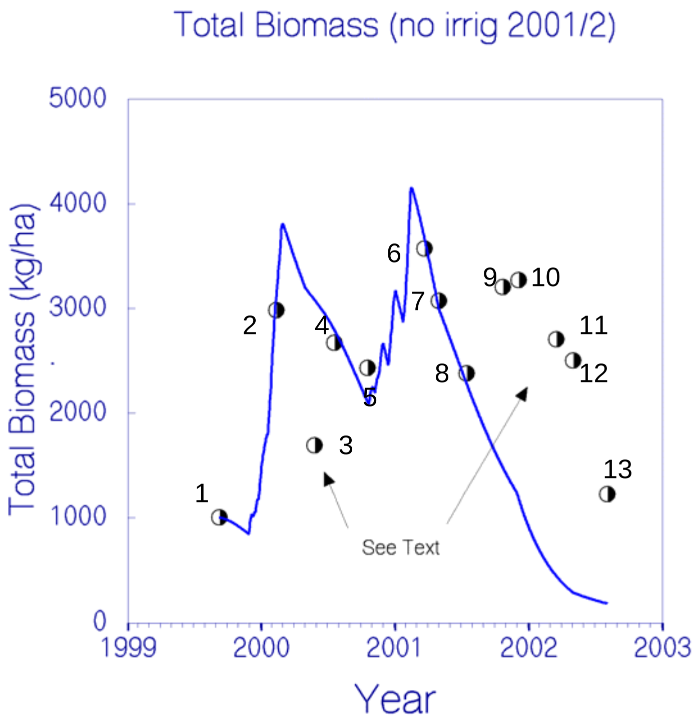
Output from a second simulation is presented (Figures 42b to 46b) which indicates that additional inputs of water (i.e. to that indicated from the NR&M rainfall surfaces) may be required to account for biomass observations (growth of annual grasses) during 2001/2 summer. The additional water in the latter simulation was arbitrarily provided in one "irrigation" in mid-September. Based on a single input of rainfall on this date - approximately 200 mm (almost a full profile) was required to simulate close to observed levels of biomass.

Modelling conclusions and recommendations

The study demonstrates that it is possible to obtain reasonable simulations of pasture biomass, soil water and cover based on the SWIFTSYND data, station rainfall and gauging station data. The study also demonstrates some of the difficulties in simulating observed biomass and soil water when records of rainfall and flooding are incomplete.

The results presented indicate that useful simulations can be obtained based on the SWIFTSYND data collected to date. It is hoped that results from this brief modelling study would encourage completion of data collection (e.g. best possible rainfall and flood records from each site/station), completion of data analysis (e.g. 2001/2 data collections) and, following this, completion of the modelling exercise for all sites. The need to obtain the best possible rainfall and flood records from each station cannot be stressed too strongly. Every attempt should be made to obtain a written and verbal history of site management, flooding and rainfall from those who collected data and station records. The high quality of data thus far collected warrants further effort to obtain missing data e.g. bulk density information. Where flood records are currently available on a site basis, effort should be made to confirm relationships between gauging station records and site inundation (or more importantly recession of floods from sites). The detailed sequence of soil water measurements thus far obtained will allow reasonable calibration of soil water parameters. The difficulty in obtaining soil water measurements immediately subsequent to flood recession is appreciated. However if it is possible to obtain such information, together with bulk density measurements, it would round off soil water collection. More detailed information as to the degree of soil cracking (if any) may also prove critical. Expert opinion will prove vital to the successful completion of the modelling exercise to fill in gaps in the data record, e.g. degree of detachment, plant death caused by inundation, initial green and dead biomass subsequent to inundation etc.

a)



Key:

Sequence	Date	observation
1	7-Sep-99	measured
2	10-Feb-00	measured
3	25-May-00	measured
4	18-Jul-00	measured
5	16-Oct-00	measured
6	22-Mar-01	measured
7	30-Apr-01	measured
8	15-Jul-01	measured
9	21-Oct-01	estimated
10	4-Dec-01	measured
11	16-Mar-02	estimated
12	1-May-02	estimated
13	2-Aug-02	BOTANAL estimate

b)

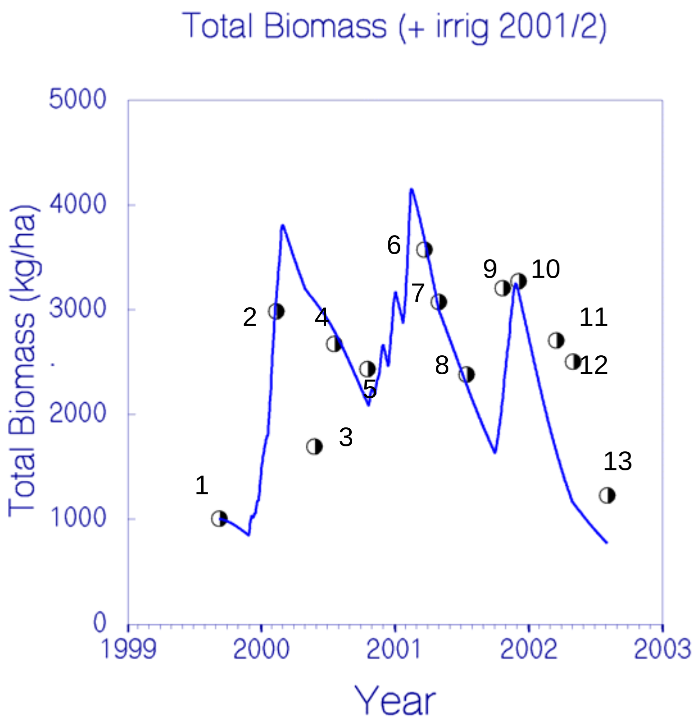
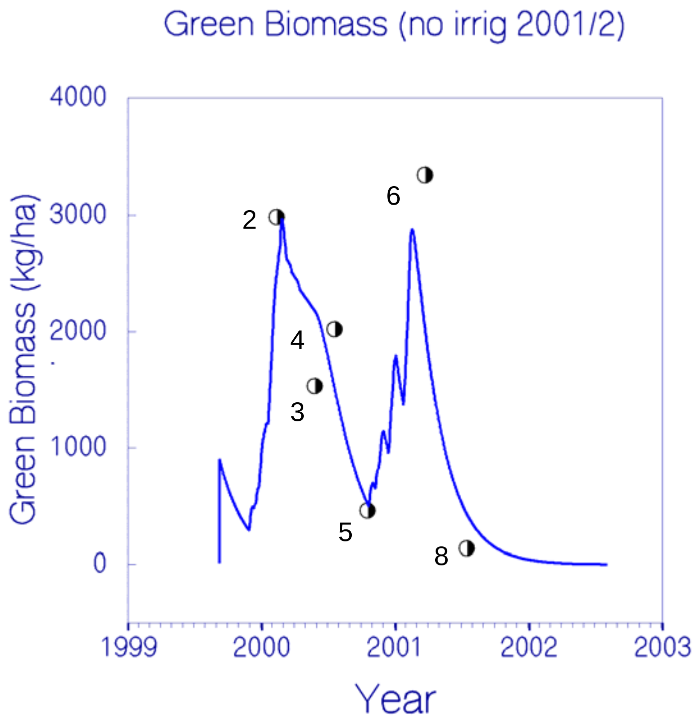


Figure 42. Predicted (symbol) vs observed (line) total biomass (kg/ha) a) without and b) with irrigation late in 2001 to simulate flooding

a)



Key:

Sequence	Date	observation
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2	10-Feb-00	measured
3	25-May-00	measured
4	18-Jul-00	measured
5	16-Oct-00	measured
6	22-Mar-01	measured
7	30-Apr-01	N/a
8	15-Jul-01	measured
9	21-Oct-01	N/a
10	4-Dec-01	N/a
11	16-Mar-02	N/a
12	1-May-02	N/a
13	2-Aug-02	N/a

b)

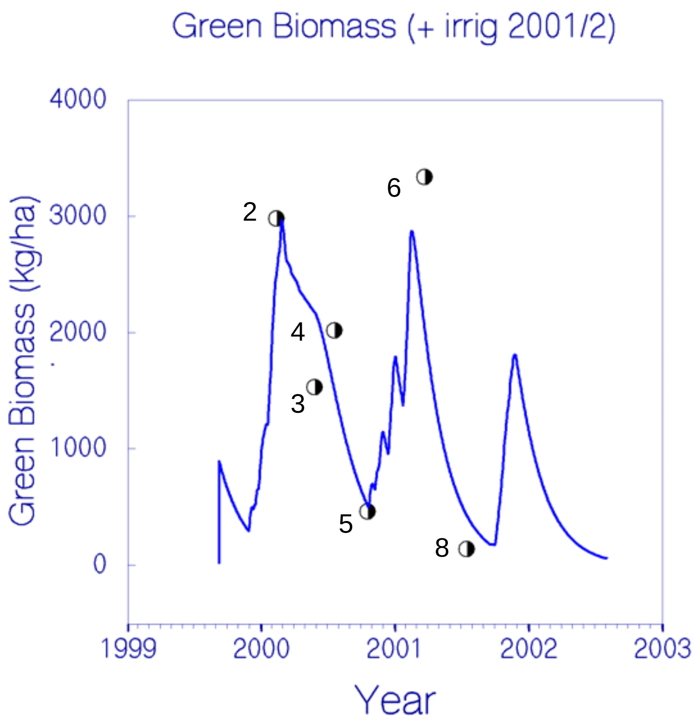
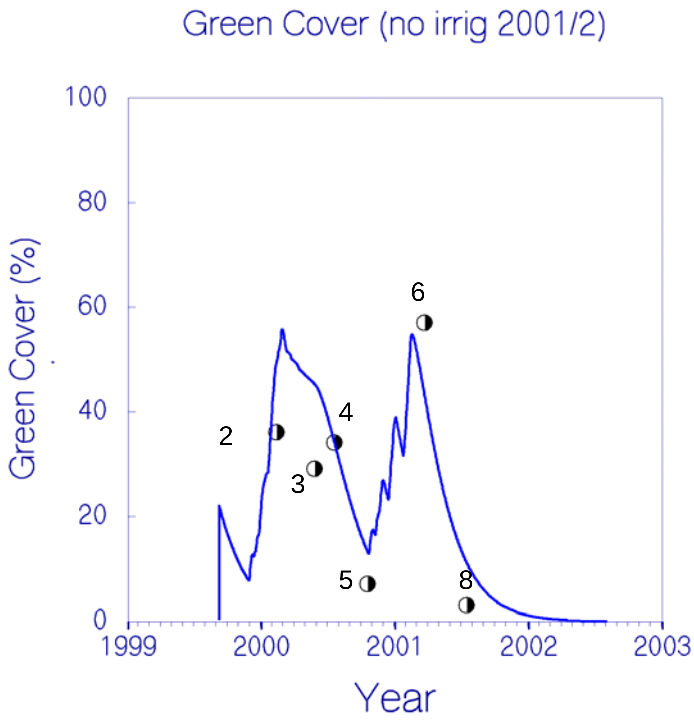


Figure 43. Predicted (symbol) vs observed (line) green biomass (kg/ha) a) without and b) with irrigation late in 2001 to simulate flooding

a)



Key:

Sequence	Date	observation
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2	10-Feb-00	measured
3	25-May-00	measured
4	18-Jul-00	measured
5	16-Oct-00	measured
6	22-Mar-01	measured
7	30-Apr-01	N/a
8	15-Jul-01	measured
9	21-Oct-01	N/a
10	4-Dec-01	N/a
11	16-Mar-02	N/a
12	1-May-02	N/a
13	2-Aug-02	N/a

b)

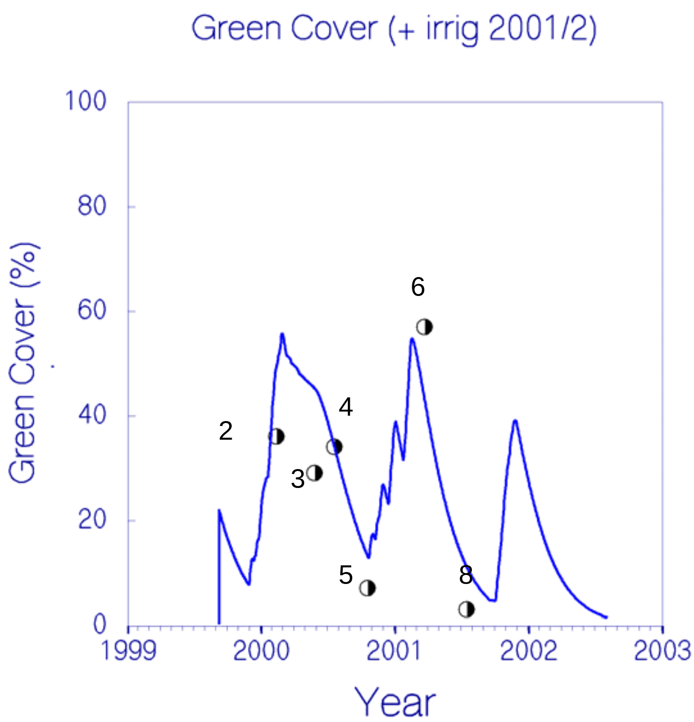
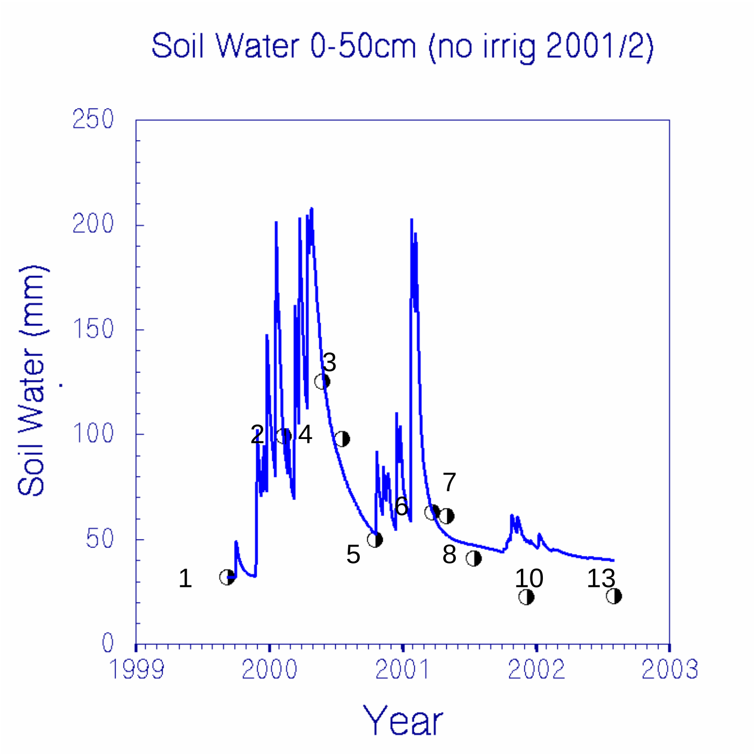


Figure 44. Predicted (symbol) vs observed (line) green cover (%) a) without and b) with irrigation late in 2001 to simulate flooding

a)



Key:

Sequence	Date	observation
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2	10-Feb-00	measured
3	25-May-00	measured
4	18-Jul-00	measured
5	16-Oct-00	measured
6	22-Mar-01	measured
7	30-Apr-01	measured
8	15-Jul-01	measured
9	21-Oct-01	N/a
10	4-Dec-01	measured
11	16-Mar-02	N/a
12	1-May-02	N/a
13	2-Aug-02	measured

b)

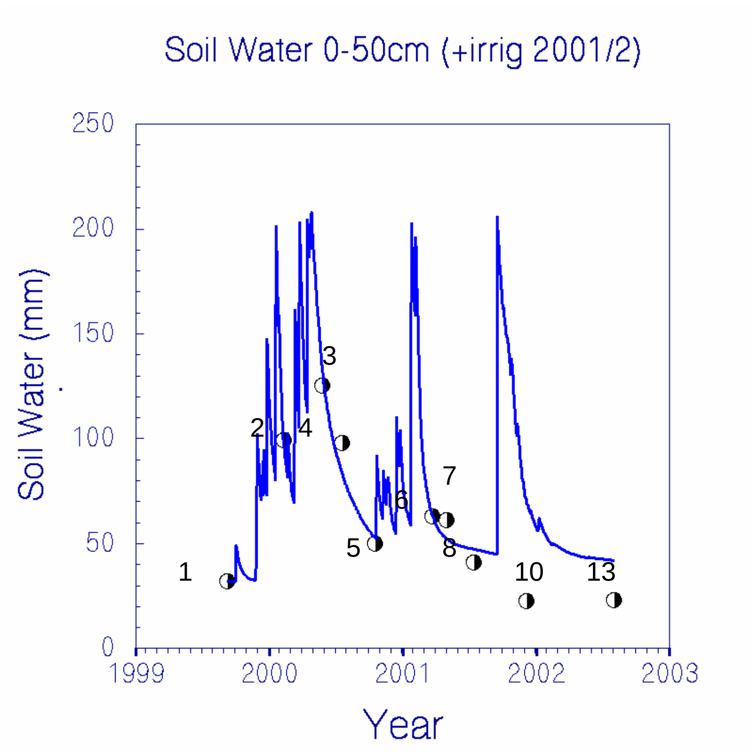
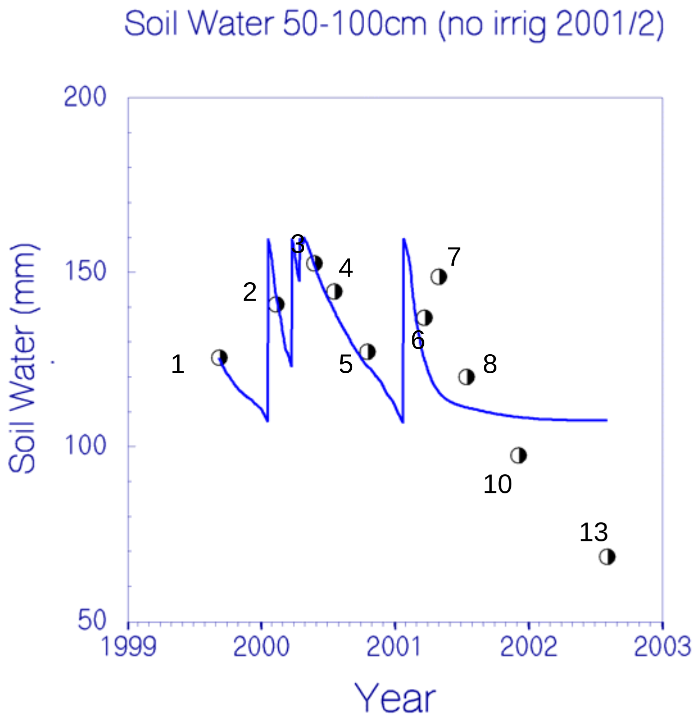


Figure 45. Predicted (symbol) vs observed (line) soil water (mm within 0-50cm depth) a) without and b) with irrigation late in 2001 to simulate flooding

a)



Key:

Sequence	Date	observation
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2	10-Feb-00	measured
3	25-May-00	measured
4	18-Jul-00	measured
5	16-Oct-00	measured
6	22-Mar-01	measured
7	30-Apr-01	measured
8	15-Jul-01	measured
9	21-Oct-01	N/a
10	4-Dec-01	measured
11	16-Mar-02	N/a
12	1-May-02	N/a
13	2-Aug-02	measured

b)

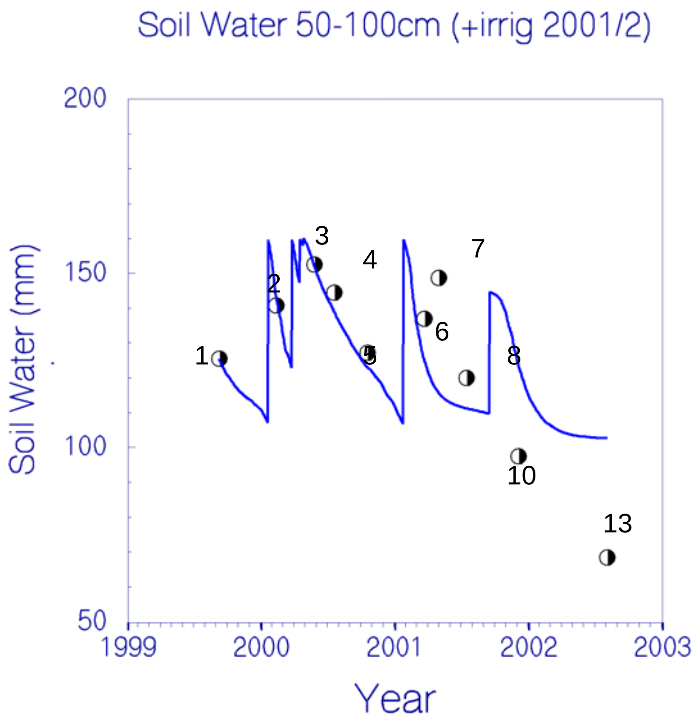
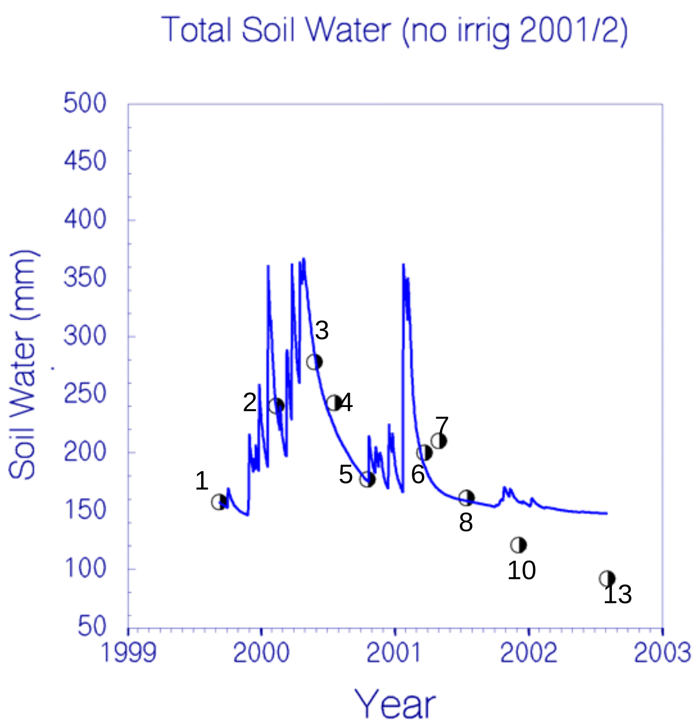


Figure 46. Predicted (symbol) vs observed (line) soil water (mm within 50-100cm depth) a) without and b) with irrigation late in 2001 to simulate flooding

a)



Key:

Sequence	Date	observation
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2	10-Feb-00	measured
3	25-May-00	measured
4	18-Jul-00	measured
5	16-Oct-00	measured
6	22-Mar-01	measured
7	30-Apr-01	measured
8	15-Jul-01	measured
9	21-Oct-01	N/a
10	4-Dec-01	measured
11	16-Mar-02	N/a
12	1-May-02	N/a
13	2-Aug-02	measured

b)

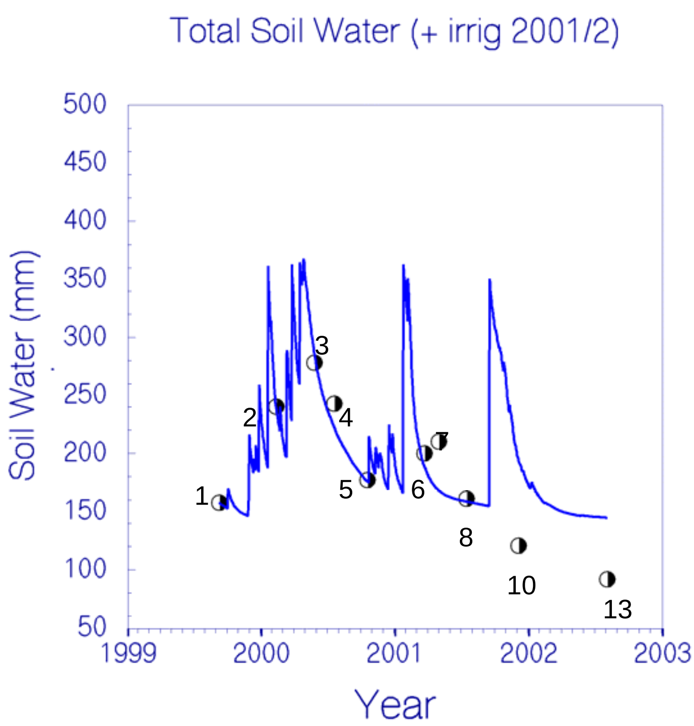

Figure 47. Predicted (symbol) vs observed (line) soil water (mm within 0-100cm depth) a) without and b) with irrigation late in 2001 to simulate flooding

CONCLUSIONS AND RECOMMENDATIONS

The project has made good progress towards providing tools to improve production and natural resource management within the floodplains of the Channel Country. The grazing community has been strongly supportive and involved, which has ensured the success of documenting current best practice through "Managing the Channel Country Sustainably. Producers' Experiences". Scientific advances in the understanding of the relationships between flood events, rainfall, soils, pastures and cattle production have been made. However, advances are needed in model calibration and application. Additionally, the project has identified a number of broader areas which require consideration.

Model calibration

Preliminary modelling of collected data through the GRASP pasture model demonstrates that it is possible to obtain reasonable simulations of pasture biomass, soil water and cover based on the Swiftsynd data, station rainfall and gauging station data. A number of specific aspects require attention to improve modelling capacity, including:

- Accurate soil bulk density recordings for each site
- Ensuring a full set of rainfall and flood records is compiled (including a written and verbal history of site management, flooding and rainfall) for each site
- Correlating gauging station records, site flood datalogger and property information for inundation and recession of floods from sites
- obtaining soil water measurements immediately subsequent to flood recession to better understand field capacity moisture levels
- A better understanding of the interaction between rainfall and flood events
- More detailed information as to the degree of soil cracking
- The completion of data analysis (e.g. 2001/2 data collections)
- The gathering of expert opinion to fill in gaps in the data record e.g. degree of detachment, plant death caused by inundation, initial green and dead biomass subsequent to inundation
- The ability to partition plant group yields, especially Queensland bluebush, and to account for the impact of lignum on pasture yields
- The collection of cattle production data through the survey forms under development
- The completion of preliminary modelling for all sites, with the close involvement of CINRS staff
- The establishment of a working group to complete modelling and to develop general parameter for each land type/species combination for the study region
- current utilisation levels be modelled on the basis of the new parameter set as an indication of potential increases in cattle production commensurate with safe resource usage

Model application

Once GRASP is working, the full benefits to the cattle industry can be realised through up-scaling the results and linking in with hydrology models, e.g. through satellite based NDVI measures and the enhanced wet/dry model being refined within the AridFlow project. Activities to determine the best approach to this issue need to be incorporate into any new research.

General issues

A number of general issues have been raised through the conduct of the project. These include[3]:

- estimating the accuracy of modelling 'outside country' Land Systems, and determining the need for Swiftsynd monitoring sites in these communities

- the need to monitor grazing impacts for the long term, as well as access existing data sources e.g. GRASS Check sites, to ensure and demonstrate sustainable production.

- the need to asses the key times of stress for the major vegetation components i.e. when will inappropriate grazing have a high probability of a causing a negative impact

- establishing base line fire information to enhance the use of fire as a management tool in Channel Country Land Systems, including spinifex, Mitchell grass, mulga and floodplain pasture communities. The could be achieved through reviewing the state of knowledge within similar country types and/or though updating an existing Campbell Scientific datalogger (at Longreach DPI) to the latest software and specifications

- the need for remote sensing pilot studies to monitor land condition, flood patterns and pasture response. For instance, a time series of the Windorah satellite image could be used to explore grazing gradients, MSDI (Mean Standard Deviation Index) and Landscape Function Analysis approaches to land condition assessment at South Galway (where 2 floodplain sites are located), as well as the vegetation response following flooding and burning. Existing Safe Carrying Capacity mapping and estimates could be incorporated and used in conjunction with local knowledge on grazing patterns to gauge the relative impacts of grazing within different land systems. This could then produce grazing management recommendations based on spatially and temporally integrated data. Can remote sensing tools or other systems/measures of greenness/pasture quality and availability be used to allow rapid and responsive livestock movements to maintain high productivity whilst preserving the natural resource?

- the need for an improved understanding of cattle grazing patterns and behaviour within a diverse and extensive landscape (eg through piloting the use of GPS livestock tracking collars to partition grazing patterns and determine relative potential impacts across Channel Country land systems)

- a responsibility to address the concerns of the environmental lobby, e.g. industry needs to address water quality and the potential impacts of grazing on stream banks and refuge water holes, as well quantifying downstream effects e.g. are sediment loads at natural levels? Is the grazing industry allowing natural water flows? If there are impacts, these need to be addressed to maintain a competitive edge in markets.

- the need to link growth rates with pasture quality, possibly through NIRS

- the need to incorporate the knowledge into EMS or other systems that will allow continuous improvement in natural resource management

- the need to ensure that all land managers within the Channel Country and other relevant areas have access to the tools developed through the project (i.e. not that they are too 'high tech' for the average manager), and that these tool are incorporated into property management to ensure their effectiveness

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[3] not in priority order

- the need to ensure that other stakeholders (e.g. universities, pastoral colleges) are aware of, and have access to, the tools developed through the project

- an improved understanding of plant nutrient levels and % of available forage i.e. what is eaten and when, what is the true nutritive level of accessible and palatable pasture

Recommendations

The authors wish to recommend that:

- data collection continue for a time sufficient to ensure GRASP modelling can reasonably accurately predict both summer and winter pasture responses to flood and rainfall events (estimated at 3 to 5 years from October 2002)

- practical tools be developed and tested during the course of this work (e.g. photostandards for yield and grazing impacts, simple measures of soil moisture)

- the inclusion of the Lake Land System, and possibly other more frequently flooded areas, be considered to allow an understanding of their role in the production system

- sampling for plant nutrient levels continue, but to be targeted at key plant species and components

- research to better understand the biology and ecology of bluebush be incorporated in current work

- a review of literature on grazing impacts in the Channel Country and similar country types be undertaken to prioritise the need to maintain existing, or establish new, long-term monitoring sites and

- the steering committee be asked to consider:

    - How the current project might change the indicators land managers use in stocking cattle (i.e. how might the models and indicators under development be applied in practice)

    - How much information is required to link scientific information and practical management guidelines in order to prepare a floodplain management guide

    - The duration of Swiftsynd monitoring they believe is required to reasonably accurately predict summer and winter pasture responses (this may require a practical workshop)

    - The role of industry and government in on-going monitoring of the natural resource base

    - The importance of other potential projects to explore remote sensing tools, fire, water quality and other big picture issues and how funding for the priority activities may be achieved

BIBLIOGRAPHY[4]

Andrew, M. H., I. R. Noble and Lange, R.T. (1979). A non-destructive method for estimating the weight of forage on shrubs. *Australian Rangeland Journal* **1**: 225-231.

Anon (2001). Kings in grass castles. Australia's great stations, and the tycoons who own them. *Outback*, **15** (March 2001): 42-60.

Anon (2002). Top 20 beef producers (by turn-off), calendar year 2001. *Feedback*, **May 2002**: i-xii.

A.O.A.C. (1980). "Official Methods of Analysis of the Association of Official Analytical Chemists", 13th Edition (Washington): Sections 3.098-3.100.

AUSLIG (1990). "Atlas of Australian Resources. Third Series. Volume 6. Vegetation". Australian Government Publishing Service, Canberra.

Brady, N.C. (1984). "The Nature and Properties of Soils (Ninth Edition)". Macmillan Publishing Company, New York. 750 pp.

Bureau of Meteorology (1997). "Flooding in Western Queensland". August 1997, <http://www.bom.gov.au/hydro/flood/qld/fld_reports/western_qld_feb1997.pdf> Accessed 2002 September 23.

Bureau of Meteorology (2000a). "Winton Flood February 2000." 23 March 2000, <http://www.bom.gov.au/hydro/flood/qld/fld_reports/winton_feb2000.pdf> Accessed 2002 September 23.

Bureau of Meteorology (2000b). "Thomson River Floods February 2000". 3 August 2000, <http://www.bom.gov.au/hydro/flood/qld/fld_reports/cooper_feb2000.pdf> Accessed 2002 September 23.

Bureau of Meteorology (2002a). "Queensland Flood Summary 1990 – 1999". 2002, <http://www.bom.gov.au/hydro/flood/qld/fld_history/floodsum_1990.shtml> Accessed 2002 September 23.

Bureau of Meteorology (2002b). "Queensland Flood Summary 2000 onwards". 2002, <http://www.bom.gov.au/hydro/flood/qld/fld_history/floodsum_2000.shtml> Accessed 2002 September 23.

Bruce, R.C. and Rayment, G.E. (1982). "Analytical Methods and Interpretations used by the Agricultural Chemistry Branch for soil and land use surveys". Bulletin QB82004, Department of Primary Industries, Brisbane. 10 pp.

Bunn, S. E. and Davies, P. M. (1995). The LWRRDC National Riparian Program: Research Issues and Opportunities for the Wet-Dry Tropics. *In* "Wetland research in the wet-dry tropics of Australia". Finlayson, C. M. Brisbane, Centre for Catchment and In-Stream Research: 266-70.

Bunn, S. E. and Davies, P. M. (1999). Aquatic Food Webs in Turbid, Arid-zone Rivers: Preliminary Data from Cooper Creek, Western Queensland (Chapter 5). *In* "A Free-Flowing River: The Ecology of the Paroo River". Kingsford, R. T. Sydney, National Parks and Wildlife Service: 67-76.

Capon, S. (1999). Zonation of Floodplain Vegetation On a Flood Frequency Gradient In a Variable, Arid-zone Catchment. Bachelor of Science Honours thesis, Faculty of Environmental Sciences, Griffith University, Nathan campus. 59 pp plus appendices.

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[4] Electronic sources have been referenced using the CBE style, as documented at <http://www.bedfordstmartins.com/online/citex.html>

Clewett, J.F. (1985). "Shallow Storage Irrigation for Sorghum Production in North-West Queensland." Bulletin QB85002, Department of Primary Industries, Brisbane. 229 pp.

Day, K.A. and Philp, M.W. (1997). "Appendix 3. Swiftsynd Methodology. A methodology for measuring a minimum data set for calibrating pasture and soil parameters of the pasture growth model GRASP". *In* K A Day, G M McKeon and J O Carter (1997). "Evaluating The Risks Of Pasture And Land Degradation In Native Pastures In Queensland" Final Report to RIRDC DAQ-124A. Department of Primary Industries, Brisbane.

Edmondston, V. (2001). "Managing the Channel Country Sustainably. Producer's Experiences". Information Series QI01022. Department of Primary Industries, Brisbane. 48 pp.

Faichney, G. J. and White, G. A. (1983). "Methods for the Analysis of Feeds Eaten by Ruminants". CSIRO, Division of Animal Production, Melbourne. 33 pp

GenStat (2000). GenStat for Windows. Release 4.2. Fifth Edition. VSN International Ltd., Oxford.

Graetz, R. D. (1980). "The Potential Application of Landsat Imagery to Land Resource Management in the Channel Country". CSIRO Division of Land Resource Management: 26 pp.

Isbell, R.F. (1996). "The Australian Soil Classification". CSIRO Publishing, Collingwood. 143 pp

Jeffrey, S.J., Carter, J.O., Moodie, K.B. and Beswick, A.R. (2001). Using spatial interpolation to construct a comprehensive archive of Australian climate data. *Environmental Modelling Software* **16**: 309-30.

Long Paddock (2002). "Rainfall and Pasture Growth Maps of Australia (1990s and 2000s). 1 September 2002, <http://www.longpaddock.qld.gov.au/RainfallAndPastureGrowth/Aus/>. Accessed 2002 September 23.

McCosker, T. and Winks, L. (1994). "Phosphorus Nutrition of Beef Cattle in Northern Australia". Information Series QI94012, Department of Primary Industries, Brisbane. 86 pp.

McKeon, G.M., Day, K.A., Howden, S.M., Mott, J.J., Orr, D.M., Scattini, W.I. and Weston, E.J. (1990). Northern Australian savannas' management for pastoral production. *Journal of Biogeography* **17**: 355-72.

McKeon, G.M., Hall, W.B., Crimp, S.J., Howden, S.M., Stone, R.C. and Jones, D.A. (1998). Climate change in Queensland's grazing lands. I. Approaches and climatic trends. *Rangeland Journal* **20**: 151-76.

Mills, J.R. (1980). Land Systems. *In* "Western Arid Region Land Use Study – Part II". Technical Bulletin No. 22 Division of Land Utilisation, Department of Primary Industries, Brisbane. 142 pp plus appendices.

Mills, J.R. and Ahern, C.R. (1980). Soils. *In* "Western Arid Region Land Use Study – Part II". Technical Bulletin No. 22 Division of Land Utilisation, Department of Primary Industries, Brisbane. 142 pp plus appendices.

Minson, D.J. and McLeod, M.N. (1972). "The in vitro technique: Its modification for estimating digestibility of large numbers of tropical pasture samples". Division of Tropical Pastures, Tech. Paper No. 8, CSIRO, Aust.

Murray, R M. and Purcell, D L. (1967). Pastures in the sheep country. *Queensland Agriculture Journal* **93**, 284-93.

OESR (Office of Economic and Statistical Research, 2001). "Local Government Area profiles". 27 November 2001. <http://ournet/_ContentRoot/(10)Useful%20Links/GovNet.asp>. Accessed 2002 August 5.

Orr, D.M. 1975: A Review of Astrebla (Mitchell grass) pastures in Australia. *Tropical Grasslands* **9**, 21-36.

Phelps, D. G. and Gregg, P. C. (1991). Effects of moisture stress on curly Mitchell grass, the common armyworm and the Australian plague locust. *Australian Journal of Experimental Agriculture* **31**: 325-31.

Rieck, K. (2000). Preliminary investigation into seed bank dynamics of the Channel Country. Bachelor of Applied Science Industrial placement report. University of Queensland, Gatton. 74 pp plus appendices.

Russell, J.S. and Greacen, E.L. (1977). “Soil Factors in crop production in a semi-arid environment”. University of Queensland Press. 327 pp.

Sweeney R.A (1989). Generic Combustion Method for Determination of Crude Protein in Feeds. *J. Assoc. Off. Anal. Chem*. **72**: 770-774.

Technical Bulletin 33 (1975). Energy Allowances and Feeding Systems for Ruminants. Ministry of Agriculture, Fisheries and Food: London. 65 pp

Tilly, J.M.A. and Terry, R.A. (1963). A two-stage technique for the in vitro digestion of forage crops. Journal of the British Grassland Society 18: 104-111.

Tothill, J.C. and Gillies, C. (1992). “The Pasture Lands of Northern Australia. Their condition, productivity, and sustainability”. Tropical Grassland Society of Australia, occasional Publication No. 5.

Tothill, J. C., Hargreaves, J. N. G., Jones, R. M. and McDonald, C. K. (1992). "BOTANAL - A comprehensive sampling and computing procedure for estimating pasture yield and composition 1. Field sampling", CSIRO Aust. Div. Trop. Crops & Past., Trop Agron. Tech. Mem. No.78.

Turner, E.J., McDonald, W.J.F., Ahern, C.R. and Thomas, M.B. (1993). “Western Arid Region Land Use Study Part V”. Department of Primary Industries Technical Bulletin no. 30, published by the Division of Land Utilisation. 205 pp.

Weston, E.J. (1988). “Native pasture communities”. *In*: Burrows, W.H., Scanlan, J.C. and Rutherford, M.T. (Eds). Native Pastures in Queensland. Department of Primary Industries, Queensland. Information Series QI87023. 284 pp.

White, I. A. (2001). "With Reference to the Channel Country. Review of available information". Information Series QI01068. Department of Primary Industries, Brisbane. 108 pp.

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The project has had a long history of leaders and key staff, with the initial NHT project funding secured by David Cobon before being handed over to Eric Anderson and Mick Sullivan to lead. Andrew White was the principal investigator from 1999 to mid 2001, with technical assistance from Sharon Robertson, prior to David Phelps assuming project leadership with technical assistance from Peter Connelly in late 2001. Michael Jeffery has provided animal production and technical expertise since the start of 2001.

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With such a long list of contributors and supports, it is inevitable that some have been overlooked from this list, and to whom we extend our sincere apologies. Your efforts have been appreciated, and this work would have been lesser without your contributions. It may just be that none of the current project has had a beer with you in the Western Star recently to remind us of your contributions.

APPENDICES

Appendix 1. Sustainable Grazing In The Channel Country Floodplains Project Steering Committee.

Appendix 2. Bureau of Meteorology flood category definitions for the Cooper, Diamantina and Georgina systems, and major historic flood heights (from BOM web site, www.bom.gov.au/hydro/flood/).

Appendix 3. Copies of available Channel Country Project communications distributed to the public.

Appendix 1. Sustainable Grazing In The Channel Country Floodplains Project Steering Committee

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Appendix 2. Bureau of Meteorology flood category definitions for the Cooper, Diamantina and Georgina systems, and major historic flood heights (from BOM web site, www.bom.gov.au/hydro/flood/).

Flood definitions used by the Bureau of Meteorology

- Major Flooding: This causes inundation of large areas, isolating towns and cities. Major disruptions occur to road and rail links. Evacuation of many houses and business premises may be required. In rural areas widespread flooding of farmland is likely.
- Moderate Flooding : This causes the inundation of low lying areas requiring the removal of stock and/or the evacuation of some houses. Main traffic bridges may be closed by floodwaters.
- Minor Flooding: This causes inconvenience such as closing of minor roads and the submergence of low level bridges and makes the removal of pumps located adjacent to the river necessary.

Cooper Creek

The Thomson-Barcoo-Cooper catchment drains an area of approximately 237,000 square kilometres and is the largest river basin in Queensland. The catchment falls within the Lake Eyre basin, the largest and only co-ordinated internal drainage system in Australia with no external outlet, and which covers over 1.1 million square kilometres of central Australia. Floodwaters reach Lake Eyre after major flood events in the Cooper.

The two main tributaries, the Thomson and Barcoo Rivers, merge into the Cooper Creek approximately 40 kilometres upstream of Windorah. The Thomson River and its tributaries flow in a general southerly direction and has several of the larger towns of the region including Longreach and Muttaburra along its banks. The Barcoo River flows in a general westerly direction and has major centres such as Isisford, Blackall, Barcaldine and Tambo in its catchment.

The Thomson-Barcoo-Cooper basin can be divided into two distinct areas:

- Above Windorah, numerous well-defined creeks and channels flow into the Thomson and Barcoo.
- Below Windorah, the typical wide ranging Channel Country develops.

In the dry season, the channels are restricted to numerous lagoons and claypans. During the wet season the actual main channel becomes hard to define, particularly when the river at Windorah could be up to 40 kilometres wide. Below this point however, in a big flood, the area becomes a huge inland sea broken only by a few ridges and numerous stunted trees.

THOMSON, BARCOO RIVERS AND COOPER CREEK CATCHMENT - ASSESSMENT OF THE FLOOD POTENTIAL

Major flooding requires a large scale rainfall situation over the Thomson, Barcoo Rivers and Cooper Creek catchment. The following can be used as a rough guide to the likelihood of flooding in the catchment :

- 75mm in 24 hours over isolated areas, with lesser rains of 50mm over more extensive areas will cause stream rises and the possibility of minor flooding. If lesser rainfalls have been recorded in the previous 24 to 72 hrs, then moderate to major flooding may develop
- 100mm in 24 hours will cause isolated flooding in the immediate area of the heavy rain
- General 100mm or heavier falls in 24 hours over a wide area will most likely cause major flooding particularly in the middle to lower reaches of the Thomson and Barcoo Rivers extending downstream to Windorah on Cooper Creek

Table 1. Major recorded flood heights at gauging stations in the Cooper Creek system.

Station	Mar 1971	Jan 1974	Apr 1990	Feb 1991	Feb 1997	Feb/Mar 2000
Muttaburra	4.19	7.80	7.15	6.65	4.50	8.10
Camoola Park	2.84	7.16	6.80	5.52		7.42
Longreach	1.97	5.47	5.04	4.38	3.60	5.62
Bogewong		8.64	7.90	6.60	5.65	8.40
Stonehenge	5.94	6.88	5.86	4.70	3.50	6.42
Jundah	7.54	8.38	7.55	6.48	4.95	7.85
Blackall			7.30		6.15	
Isisford		6.83	9.20	4.25	8.05	
Retreat			12.05	6.55	9.45	
Windorah	7.65	8.48	7.95	6.70	5.87	7.45
Durham Downs		4.40	4.16	2.15	2.80	3.65
Karmona			5.38	4.29	4.05	
Nappa Merrie	5.91	10.13	9.38	3.20	2.51	5.10

All heights are in metres on flood gauges.

Table 2. Flood height levels for gauging stations in the Cooper Creek system.

Station	First Report Height	Crossing Height	Minor Flood Level	Crops & Grazing	Moderate Flood Level	Towns and Houses	Major Flood Level
Muttaburra	3.0	4.0 (B)	3.0	6.0	5.0	8.2	7.0
Aramac	1.3	1.8 (B)	1.5	1.7	2.0	5.4	5.0
Camoola Park	1.0	0.4 (X)	2.0		4.0	8.0	6.7
Longreach	1.0	2.2 (OB)	2.0	3.0	3.0	5.4	4.0
Bogewong	0.3	3.1 (B)	2.0	3.0	4.0		6.0
Stonehenge	0.5	1.6 (A)	2.0	1.0	3.0	10.0	5.0
Jundah	1.0	3.7 (A)	2.5	5.0	4.0	4.6	5.0
Tambo	2.5	2.9 (B)	3.0	5.1	5.1	5.9	5.9
Gillespie	3.5	6.4 (B)	4.0	6.5	7.0		7.5
Duneira	1.0	1.4 (B)	2.0		3.0		3.5
Blackall	1.0	2.8 (B)	2.0	4.0	4.0	5.5	5.0
Glencoe	1.0	1.0 (X)	2.0		2.5		3.0
Jericho	1.8	2.3 (B)	2.0	2.3	2.3	3.0	3.0
Barcaldine	2.0	5.6 (B)	3.0		5.0		6.0
Isisford	2.0	4.0 (B)	4.0	4.0	5.0(d/s)		6.0(d/s)
Retreat	2.0	1.7 (C)	3.0	5.0	4.0		5.0
Windorah	3.0	4.3 (A)	3.0	5.0	4.0		5.0
Nappa Merrie	1.5	8.0 (B)	3.0	4.0	6.0		9.0

All heights are in metres on flood gauges. (B) = Bridge (OB) = Old bridge (A) = Approaches (C) = Causeway (X) = Crossing (d/s) = Downstream

Diamantina River

The vast Diamantina River catchment is located in south west Queensland and covers an area of approximately 119,000 square kilometres. The river rises in the Swords Range, 70 kilometres southwest of Kynuna and flows initially in a north and easterly direction before changing to a south-westerly direction 70 kilometres west of Winton. Major tributaries joining the river are the Western and Mayne Rivers above Diamantina Lakes and Farrars Creek below Monkira. The river does not have a well defined main channel but consists generally of a series of wide relatively shallow channels. The river passes through the town of Birdsville before crossing the Queensland-South Australia border 10 kilometres south of Birdsville. Floods normally develop in the headwaters of the Diamantina River and its major tributaries, however, flooding may result from heavy rainfall falling in the middle to lower reaches of the catchment around Diamantina Lakes. Local area rainfalls can be a significant factor throughout these areas.

The main impact of the record major flooding in January 1974 at Birdsville, and more recently the floods of 1991 and 2000, is the isolation of towns and properties and the extensive inundation of grazing lands which can last several months in some areas, with road transport disrupted for considerable periods of time.

The table below (Table 3) summarises the flood history of the Diamantina River basin - it contains the flood gauge heights of the highest know floods recorded at selected river height locations, together with heights of recent floods.

DIAMANTINA RIVER CATCHMENT - ASSESSMENT OF THE FLOOD POTENTIAL

Major flooding requires a large scale rainfall situation over the Diamantina River catchment. The following can be used as a rough guide to the likelihood of flooding in the catchment:

- 75mm in 24 hours over isolated areas, with lesser rains of 50mm over more extensive areas will cause stream rises and the possibility of minor flooding. If lesser rainfalls have been recorded in the previous 24 to 72 hrs, then moderate to major flooding may develop.
- 100mm in 24 hours will cause isolated flooding in the immediate area of the heavy rain.
- General 100mm or heavier falls in 24 hours over a wide area will most likely cause major flooding in the middle to lower reaches of the Diamantina River between Tulmur and Diamantina Lakes extending downstream to Monkira and Birdsville.

Table 3. Major recorded flood heights at gauging stations in the Diamantina River system.

River height station	Highest recorded flood (in metres)		Mar 1950	Mar1971	Feb 1976	Mar 1977	Feb 1991	Jan 1999	Feb/Mar 2000
Elderslie	Feb 2000	2.94							2.94
Aldingham	Feb 2000	2.66							2.66
Oondooroo	Feb 2000	4.11							4.11
Winton	May 1955	5.01	4.47						4.65
Tulmur	Jan 1974	9.75						4.70	7.65
Diamantina Lakes	Jan 1974	7.06		5.99	6.62	5.33	5.50	6.40	5.90
Monkira	Feb 1974	6.12	5.79	5.03	5.25	4.45	4.80	5.10	4.80
Birdsville	Feb 1974	9.45	8.54	8.08	8.20	7.90	8.20	7.40	7.35

All heights are in metres on flood gauges.

Table 4. Flood height levels for gauging stations in the Diamantina River system.

River Height Station	First Report Height	Crossing Height	Minor Flood Level	Crops & Grazing	Moderate Flood Level	Towns and Houses	Major Flood Level
Elderslie	1.5	1.6 (C)	1.5	2.5	2.5		3.0
Apsley	1.5		2.0		2.5		3.0
Aldingham	1.0		1.5		1.7		2.0
Oondooroo	1.0	0.6 (C)	2.0		3.0		4.0
Winton	1.3	1.3 (B)	1.5		2.0		3.5
Tulmur	4.0		5.0	7.0	7.0	9.0	8.0
Diamantina Lakes	0.3	0.0 (X)	1.0	1.0	3.0	7.0	5.0
Monkira	2.0	2.6 (A)	2.6		4.0		5.0
Birdsville	2.0	4.0 (A)	4.0	4.0	6.0	7.9	8.0

All heights are in metres on flood gauges.

Georgina River and Eyre Creek system

The Georgina River and Eyre Creek system drains an area of approximately 210,000 square kilometres. It rises to the north west of Mt Isa with three main tributaries, the Buckle, Sander and Ranken Rivers. The latter two have their headwaters in the Northern Territory. Further inflow enters the system from numerous creeks and rivers, the two main tributaries being the Burke and Hamilton Rivers. The Burke River drains the area to the north of Boulia and enters the Georgina River about 20 kilometres upstream of Marion Downs, whilst the Hamilton rises to the northeast of Boulia and enters the main Georgina below Marion Downs. Towns located within the catchment include Urandangie, Dajarra, Boulia and Bedourie.

Very little rainfall is needed to bring the country to a standstill. Following flood rains, the main channel fills fairly quickly and then spreads out into the neighbouring channels and watercourses for kilometres on either side. In the event of severe flooding, the Georgina can vary in width in the upper reaches from 15 to 20 kilometres, and in the lower reaches it is estimated in some sections to be 25 to 30 kilometres wide.

The main impact of flooding is the isolation of towns and properties and the extensive inundation of grazing lands which can last several months in some areas. Road transport is disrupted for long periods

The table below (Table 5) summarises the flood history of the Georgina River and Eyre Creek basin - it contains the flood gauge heights of the highest know floods recorded at selected river height locations, together with heights of recent floods.

GEORGINA RIVER AND EYRE CREEK CATCHMENT - ASSESSMENT OF THE FLOOD POTENTIAL

Major flooding requires a large scale rainfall situation over the Georgina River and Eyre Creek catchment. The following can be used as a rough guide to the likelihood of flooding in the catchment:

- 75mm in 24 hours over isolated areas, with lesser rains of 50mm over more extensive areas will cause stream rises and the possibility of minor flooding. If lesser rainfalls have been recorded in the previous 24 to 72 hrs, then moderate to major flooding may develop.
- 100mm in 24 hours will cause isolated flooding in the immediate area of the heavy rain.
- General 100mm or heavier falls in 24 hours over a wide area will most likely cause major flooding in the middle to lower reaches of the Georgina, Burke and Hamilton Rivers extending into Eyre Creek, downstream of Marion Downs.

Table 5. Major recorded flood heights at gauging stations in the Georgina River system.

Station	Highest recorded flood (in metres)		March 1972	Feb/Mar 1977	Feb/Mar 1991	Feb/Mar 1993	March 1997
Urandangie	Jan 1974	7.45*		7.32	3.75	4.10	7.30
Glenormiston	Jan 1974	8.89	7.03	8.78	4.95	5.50	8.15
Boulia (Burke River)	Jan 1974	5.96	5.94	5.35	4.40		5.70
Marion Downs	Jan 1974	7.42	6.25	6.91	6.20	4.92	6.65
Glengyle (Eyre Creek)	Feb 1974	6.45	4.51	5.74	5.15	3.15	5.65

All heights are in metres on flood gauges.[*] This height was obtained from a surveyed flood mark.

Table 6. Flood height levels for gauging stations in the Georgina River system.

River Height Station	First Report Height	Crossing Height	Minor Flood Level	Crops and Grazing	Moderate Flood Level	Towns and Houses	Major Flood Level
Urandangie	0.5	0.2 (X)	1.0		5.0	7.0	7.0
Glenormiston	3.0	2.6 (B)	3.0	3.0	4.0		6.0
Boulia	3.0	4.9 (B)	4.0	4.0	5.0	6.1	6.0
Marion Downs	1.0	3.5 (B)	3.0	3.0	4.0		5.0
Glengyle	1.0	3.3 (B)	2.0		3.0		4.0

All heights are in metres on flood gauges.(B) = Bridge (A) = Approaches (C) = Causeway (X) = Crossing

Appendix 3. Copies of available Channel Country Project communications distributed to the public.

"The Channel Country Floodplains" by Andrew White (1999)

"Early Research Gives Channel Country Management A Tick" – DPI Press Release

Current version of project information leaflet (the project flyer)

Examples of project newsletters (issues 1 and 10; back issues are available on request)

Other articles (not appended) include:

- "Lessons learned in Channel Country sustainability" (Feedback 2002)
- "Tapping a vast stream of local knowledge" (Feedback 2002)

THE CHANNEL COUNTRY FLOODPLAINS

The Channel Country is unique. This 'natural irrigation' system is a significant part of one of the largest inland drainage basins in the world. The three major river systems of the Channel Country, Cooper's Creek, the Diamantina and Georgina Rivers, have a total catchment area of around 700,000 km^2. Floods can be variable and unpredictable, and despite the large catchment area there can be significant periods with zero flow, Cooper's Creek recording the longest period of 21 months in 1951/52. The largest annual discharge of more than 23 million megalitres was recorded in 1974 in the Cooper (the volume of an Olympic swimming pool is just over 2 megalitres, and Sydney Harbour is around half a million megalitres).

The Channel Country has both pastoral and environmental significance. The most common land use for the last 120 years has been cattle grazing. In such a varied environment it is difficult to predict the conditions that will prevail from month to month, let alone from year to year and important management decisions have traditionally been based on experience. A project has been underway for the past six months to provide a more factual basis on which management decisions can be made. The idea for the project came out of a realisation from the major pastoral companies of a lack of objective information concerning the natural and production systems in the Channel Country.

The Sustainable Grazing on the Channel Country Floodplains (SGCCF) project is targeted at developing an objective assessment of ecologically sustainable grazing of the floodplains of the Channel Country. Information to be measured and recorded includes:

- Flood details; height duration, timing,
- Beef production from the floodplain areas,
- Pasture growth following defined flood events, and
- Pasture condition from the receding of the flood till haying off.

The project focuses on the flood out country in the Georgina and Diamantina Rivers and Cooper's Creek, and will be run in five parts. These are:

1. Document available knowledge of the performance and management of the channel country by speaking to those people who live in and manage this country.
2. Collect all background information; historic, scientific, photographs, videos etc.
3. Obtain objective data on pasture response and cattle production following flood events through monitoring exclosures.
4. Produce two publications "Managing Channel Country Pastures" and "Plants of the Channel Country" and use the data obtained to model pasture growth from flood details.
5. Hold a series of workshops in the Channel Country to discuss the project, its outcomes and its value.

A commitment has been made for part funding by the Natural Heritage Trust and support from the four major pastoral companies and other Queensland and South Australian Government Departments for a three year period. Due to the short time frame of the project the focus will be on the channel floodplains.

As the project progresses I will update the information, both what we have done and what we have found. If you want to discuss the project contact Andrew White at Longreach DPI on 4658 4444.

Queensland Government
Department of Primary Industries

NEWS RELEASE

1 May 2001

EARLY RESEARCH GIVES CHANNEL COUNTRY MANAGEMENT A TICK

Early Department of Primary Industries research results are tending to confirm the value of grazing management practices in the Channel Country of far western Queensland and northern South Australia.

The grazing practices are documented in a report called Managing the Channel Country Sustainably - Producers' Experiences, which has just been released.

The trial results are coming from a DPI Agency for Food and Fibre Sciences project - Sustainable Grazing in the Channel Country Floodplains

The report, funded by the National Heritage Trust and Meat and Livestock Australia, records the experiences of the area's managers - how the vegetation of the Georgina, Diamantina rivers and Cooper Creek responds to different floods and how they manage the large cattle herds that grow and finish on the resulting pasture.

According to the DPI Rangeland Scientist, Andrew White of Barcaldine, the project's research objectives are to understand what happens after a flood and ensure that the production management of the resulting vegetation is sustainable.

"The report is an invaluable part of the project, with its 600 years of experience that the current managers have in the area," Mr White said.

"Because they must alter their management according to the vegetation responses of the river, they have found that observing the rivers carefully gives them the best practical knowledge of how the system works and how it should be managed for the best results.

"This provides direction to the research component as to what areas should be monitored for a better understanding of why events occur and whether the current management is affecting the natural vegetation."

He said that research results just starting to come together were generally supportive of current management practices.

Report compiler Vince Edmondston, of Toowoomba, said it was the result of personal interviews with many Channel Country managers. Interviews were compiled with emphasis on common themes, as well as highlighting the variation in opinions.

He said that while the river tended to behave differently on every property and between every flood there were common 'rules of thumb' applied over the whole system.

“An example, a 'rule of thumb' is that a flood that holds its peak for a longer period will push out further to cover a greater area of the floodplain.

“Managers were more than happy to talk about their experiences of the river and had a real passion for looking after the river,” he added.

Major contributors to the project include Stanbroke, Australian Agriculture, North Australia Pastoral Company and Kidman.

Copies of Managing the Channel Country Sustainably - Producers' Experiences are available from ????

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