THE PRODUCTION, ECONOMIC AND ENVIRONMENTAL IMPACTS OF TREE CLEARING IN QUEENSLAND

A REPORT TO THE WORKING GROUP OF

THE MINISTERIAL CONSULTATIVE COMMITTEE ON TREE CLEARING

Edited by

JC Scanlan and EJ Turner
Department of Lands

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This report was prepared by a Scientific Forum with the following membership:

Department of Lands

Joe Scanlan
Ed Turner
Pat Lyons
Elton Miller
Jim Walls
Geoff Edwards

Department of Environment and Heritage

Des Boyland
Bruce Wilson
Peter Stanton
Gethin Morgan
Stephen Barry
Keith Claymore

Department of Primary Industries

Bill Burrows
Eric Anderson
Bob Miles
Bob Shepherd
George Bourne
Blair Bartholomew
Tony Constantini

Readers of this document are encouraged to read the referenced documents where there is a need to quote information. Opinions expressed in this paper are those of the contributors and not necessarily of the Departments they represent.

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1.0 EXECUTIVE SUMMARY

• Queensland has a total area of 173 Million ha, 117 M ha of which supported woody vegetation (forests, woodlands and shrublands) in its natural state. It is estimated that 35% of this woody vegetation has been cleared or severely modified. About 2.1 M ha of forests and woodlands are contained in conservation reserves and a further 14 M ha are contained within State forests and timber reserves. A satellite monitoring program has been implemented to accurately assess the extent of tree cover over the whole State.

• About 80% of Queensland is leasehold land, subject to tree clearing permits under the *Land Act 1962, 1994*. Freehold land (freehold land and freeholding leases are mainly located in the more favourable climatic regions) is not subject to such controls. Some local governments have vegetation control local laws, but these have not been applied to broadscale woodland management. Similarly, conservation orders can be issued on all tenures under the *Nature Conservation Act*, but they are intended for specific purposes.

• The challenge facing resource managers in the 1990s is sustainable economic and ecological development and multiple resource use. All levels of government need to consider both public and private interests in managing State land.

• The Government is a signatory to the National Strategy for Ecologically Sustainable Development (ESD) whereby environmental considerations must be factored into the decision-making process with other policy imperatives such as economic development, trade and employment. The ecological objectives of ESD and resource sustainability may be met through a combination of the land tenure system and ecological land management.

• This report focuses on leasehold land where the principal land use is the raising of livestock and/or the growing of crops for agricultural production. Grazing is by far the most significant land use in terms of area involved.

• The most intensively cleared regions are in the coastal and subcoastal lands, progressively decreasing in the degree of clearing with distance from the south-east corner and the eastern coast. The brigalow *(Acacia harpophylla)*, gidgee (*A. cambagei*) and softwood scrub communities are the most intensively utilised communities, resulting in part from Government-sponsored development schemes which were designed to exploit the high production potential. About 60% of the original tree cover has been removed from brigalow/gidgee regions.

• Inappropriate grazing management practices are primarily responsible for increased run-off and erosion and changes in herbaceous cover and composition. Tree clearing alone is not generally a cause of increased runoff and soil erosion. Trees compete directly with pasture for water and nutrients, generally resulting in less pasture cover under trees than in cleared areas. Poor pasture and grazing management and the lack of fire may have greater impacts than the direct effects of tree clearing. A consequence of current management practices is that tree density and biomass is increasing in many of the State's uncleared grazed woodlands.

• The greatest threat to biodiversity is loss of habitat. Even under the Draft State Guidelines for Broadscale Tree Clearing, it is considered that biodiversity will decrease in some vegetation associations.

• Of the 924 regional ecosystems[1] currently recognised in Queensland by the Department of Environment and Heritage:

- 71% are still relatively abundant in the landscape and at present are of no concern in regard to the loss of biological diversity, and

- 29% of ecosystems are potentially vulnerable or threatened in terms of loss of biodiversity with clearing and grazing being major contributors to this potential loss. (These ecosystems occur mainly in the brigalow belt and SE Queensland).

• The conservation of biodiversity is achieved through the reserve system, but also through regulation (tree clearing permits) and formal agreements with landholders.

• Adequate wildlife corridors and the appropriate retention of remnant vegetation are essential elements of nature conservation planning in maintaining regional biodiversity. The required sizes of remnant vegetation areas and the recommended sizes of patches and widths of corridors are difficult to quantify but guiding principles have been established. An important general principle is that reserves must be large enough to encompass the full range of habitat types and the ecological links between them.

• The importance of riparian zones in maintaining biodiversity is recognised, and tree clearing restrictions should apply to these areas. The buffer widths vary, depending upon the category of the zone.

• Clearing of native trees and shrubs in Queensland generally increases pasture production. Pasture production is increased from 2 to 4 times when woody plant competition is removed (in eucalypt communities). The greatest increases are where trees are initially the most dense and where soil fertility and rainfall are at moderate levels. Increases of 2-3 fold are recorded for cattle liveweight gains per hectare by removing eucalypt competition, and the extra pasture cover also lowers the risk of erosion. Other advantages of clearing woodlands include improved stock handling, better dietary choice, pasture oversowing with introduced species, and fodder tree establishment.

• The disadvantages of tree clearing include loss of habitat and biodiversity, potential increase in salinisation in susceptible landscapes from altered hydrological regime, reduced cycling of soil nutrients from deep soil layers, reduced shade and shelter, a more extreme micro-environment, woody regrowth, and loss of timber resources. Some effects of tree clearing are apparent on site while other effects, such as changes in salinity status or catchment hydrology, are manifested offsite and at the regional scale. Future land use options such as native timber production, tourism and nature conservation may be adversely affected by broadscale tree clearing.

• The production and economic benefits (to graziers and the State), of responsible tree management are quite a substantial component of the annual ~$5 billion of crop and livestock production in Queensland.

• The contribution of tree clearing and land use change to the National Greenhouse Gas Inventory (NGGI) is overstated as increases in woody species density and biomass, and native and exotic

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[1] Note that these were recognised for conservation purposes and not specifically for tree clearing. Some contributors did not agree that these were an appropriate base for developing tree clearing guidelines.

shrub invasions in the grazed woodlands were excluded from the calculations. When these are considered, agricultural land is a positive 'sink' and not a net emitter as originally proposed by the NGGI. Any management to reduce density or biomass within grazed woodlands would reduce this sink strength.

• There is an estimated potential to profitably develop 50% of the current grazed leasehold woodlands[2], and increase the State's cattle herd by some 2 million head. At the estimated rate of clearing used in the National Greenhouse Gas Inventory, this would take some 70-100 years to achieve.

• Regrowth management on cleared land must be a component of any tree clearing program to maintain pasture production. This is not a problem where cultivation is undertaken following clearing. Any increase in woody plant density and biomass is potentially damaging in pastoral production systems. This not only affects the treated area but total grazing pressure increases on the remainder of the property.

• Cost-effectiveness and financial evaluation (of individual properties) is only one component of the full economic analysis of tree clearing. These analyses are conducted from the perspective of the individual rather than from the viewpoint of society as a whole. The *net social benefit* takes into account all benefits and costs (including the value of unpriced goods such as biodiversity and visual amenity). While highly desirable, this approach is difficult to undertake for issues such as tree clearing.

• An analysis of the value of properties in part of Zone 6 in Central Queensland (since the release of the Draft State Guidelines) reveals that property values potentially could possibly be reduced by 15% to 70% for partially or undeveloped leasehold properties. Many undeveloped leasehold properties are considered unsaleable in the current climate of uncertainty. Values for fully developed properties remain largely unaffected. Similarly, it is considered that values of properties with very limited potential for broadscale tree clearing will not be affected.

• A limited and preliminary analysis of farm profitability[3] on largely undeveloped properties, indicates that for every 10% increase in clearing rate, annual net profits and land values are increased by:

- 20 cents/ha, and $3.70/ha respectively in poplar box country; and
- 18 cents/ha, and $3/ha respectively in mulga country.

• Most research work associated with tree management has been related to: grazing land management; the compilation of land resource inventories; and the assessment of land capability. Soil chemical, biological and physical responses to tree clearing have been documented in relatively few of the major ecosystems within Queensland.

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[2] Not all members of the Scientific Forum agreed that this was a sustainable level of development.

[3] The report by DPI on *New Timber Clearing Guidelines: The likely impact on farm profitability in two clearing zones* has previously been provided to the Working Group and is not included in this document.

2.0 PURPOSE OF THE PAPER

The Terms of Reference of the Scientific Forum were:

> *To provide the MCC [4]Working Group with a comprehensive scientific assessment of environmental, economic and production impacts of tree clearing having due regard to the Government's stated objectives on tree clearing and the Draft State Guidelines on Broadscale Tree Clearing.*

This paper is a collation of scientific information relevant to all aspects of tree clearing and is not an interpretive review of that information. The majority of information is published. No conclusions are drawn from that information nor any specific implications made for the Draft State Guidelines.

The document applies to grazed leasehold land and does not cover all possible situations where tree clearing is practiced. It does not cover forestry and other specialised agricultural industries. It does not refer to tree clearing in sensitive areas such as steep lands, highly erodible soils or in riparian areas - these are directly protected by provisions in the *Land Act 1994*.

While an attempt has been made to provide a comprehensive review, not all issues have been covered in equal depth. A majority of the research reported here has an agricultural production focus. This is a reflection of the amount of research conducted and available, rather than any bias in the compilation of this report. Some of the issues not coverd in detail include induced salinisation, eucalypt dieback, soil acidification, weed introduction and spread, soil biology and general consideration of local and regional ecosystem processes.

The research reported here has usually been done on specific areas within the State, rather than covering the whole State. There may be cases where the limitations of scope of the work is not well reported, and care must be taken when conclusions are drawn or inferred for the State. Where readers wish to quote information, it is recommended that the original material is read to ensure that the full context is apparent.

Appendix 1 considers in detail each element of Table 1 of the Draft State Guidelines; Appendix 2 describes the major pasture associations in Queensland; Appendix 3 provides a preliminary analysis of trends in property valuations in central Queensland; and Appendix 4 provides a glossary of scientific and common plant names.

3.0 HISTORY OF LAND DEVELOPMENT

3.1 Pre-settlement conditions

There are some 173 million hectares in Queensland of which about 56 million hectares are community types that have few if any trees in their natural state (data extracted from Weston *et al.* 1981). The majority of the remaining 117 million hectares would have had a significant level of tree cover in its natural state, although the actual area is not known accurately. An estimate from Danaher *et al.* (1992) is that 76 million hectares currently support forest, woodland or shrubland. This represents 65% of the original tree cover.

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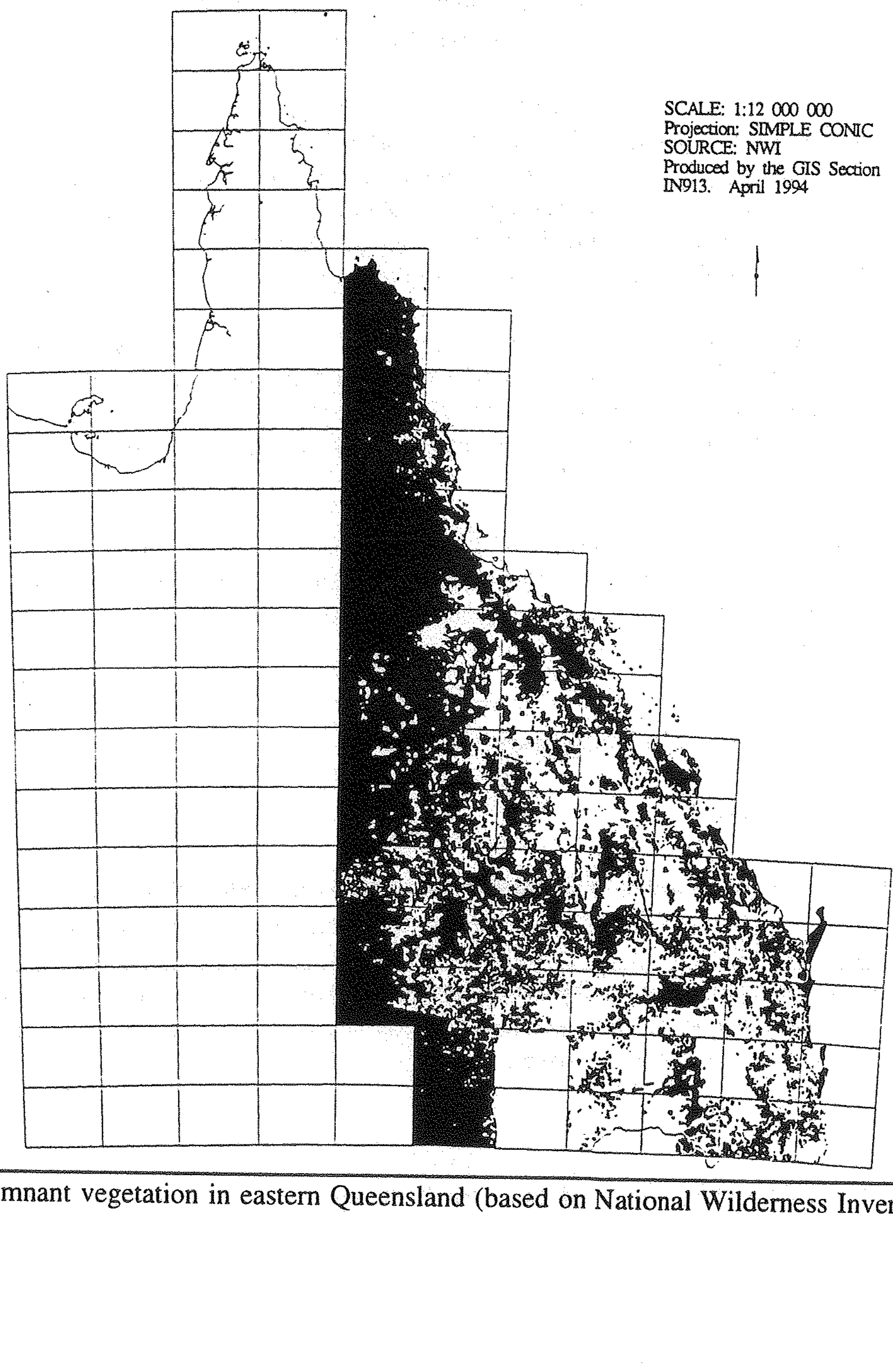
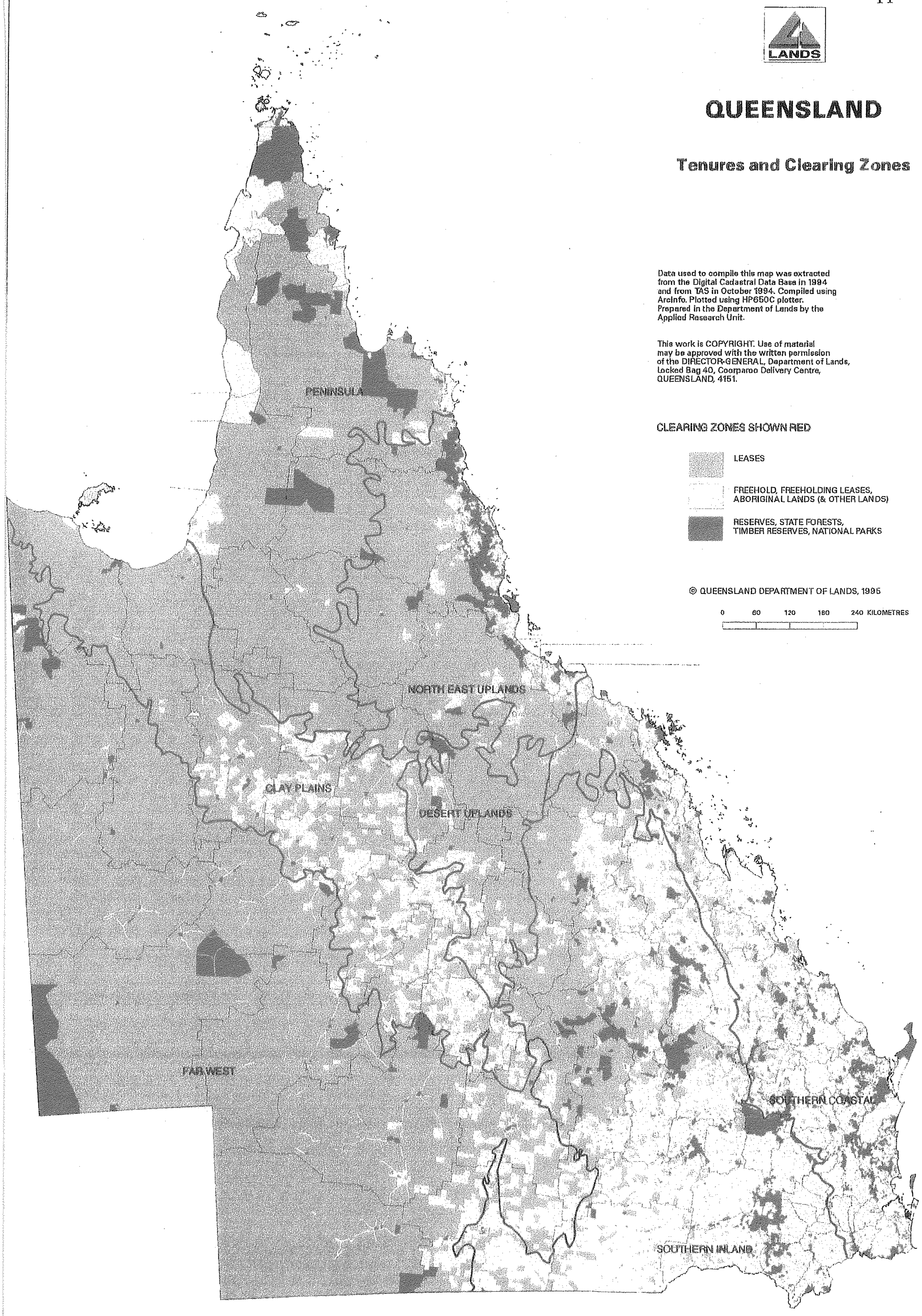
[4] The Ministerial Consultative Committee on tree clearing was formed on 3 April 1995.

Remnant Vegetation in Eastern Queensland
(Preliminary Edition)

Whole State	172 million hectares	100%
Study Area	101 million hectares	59%
Remnant Vegetation (natural cover) within Study Area	49 million hectares	49% of Study Area



Map 1. Remnant vegetation in eastern Queensland (based on National Wilderness Inventory).



Map 2 Tenure and clearing zones

3.2 Tree clearing

3.2.1 *Stages in development*

The economic development of the colony and later the State of Queensland was closely linked to the pastoral industry. The fortunes of this industry (which was reliant on the seasons and external markets) were reflected in the well-being of the community. Further, the manufacturing or secondary industries were dependent on primary industries since they provided the market for the products. Hence when primary industries suffered, the recession was felt throughout the nation.

Because of this, the development of the pastoral industry became a priority of early Governments. This development was driven in part by closer settlement schemes and various incentives were established for land development which incorporated land clearing.

Various Land Acts provided a framework which enabled the development of the land and delivered economic rewards to landholders. The leasehold system gave graziers security of tenure, enabled resources to be used for development rather than the purchase of land and provided incentives through lease conditions and rental discounts for land development and improvement. This was complemented by the generous taxation allowances which provided further economic incentives for land development at that time.

It is possible to identify some keys stages in the overall development of Queensland's agriculture as it relates to tree clearing:

• Early development was associated with clearing for cropping, and involved felling trees with axes and digging out or the burning of tree stumps.

• The next phase was ringbarking trees to increase growth of pastures. This allowed much greater areas to be treated and was a suitable method when labour was cheap. This phase lasted until the 1950s.

• After World War II the availability of heavy machinery (surplus war equipment) gave further impetus to land development. The development of chemicals for stem injection gave tree 'clearing' another dimension. This was complemented by the development and introduction of improved pasture grasses and legumes.

• Initially chaining/pulling was limited by the power of machines and appropriate techniques. Larger tractors became available in the early 1960s and were extensively used in the Brigalow Land Development Scheme. Continued increases in the power of machines led to their use in eucalypt communities. Most clearing is currently undertaken using a large chain pulled by two bulldozers.

• The herbicide 2,4,5-T was not particularly effective on eucalypts when used as a stem injection technique in the 1960s. However when picloram-based herbicides (Tordon®) became available from the 1970s, extensive areas began to be cleared using this technique.

• GRASLAN® was introduced in the early 1980s and showed great potential despite its high cost. Its usage to date has not been in parallel with its potential, probably due to high costs.

• Blade ploughs are particularly effective for regrowth control of root-suckering species. Since 1980, they have become popular in Queensland, despite their high cost.

3.2.2 *Extent of clearing*

The degree of clearing varies across Queensland with the main determinants being total rainfall and soil type - higher rainfall areas and more fertile areas have been cleared to a greater extent for farming and grazing. This results in a progressive decrease in the degree of clearing with distance from the south-east corner and the east coast (Burrows *et al.* 1988a).

No accurate figures exist for the total areas that have been cleared within Queensland. An estimate based on 1982/83 Australian Bureau of Statistics was that some 16% of the total area of the State (or about 25% of those areas in the State where woody vegetation was an important part of original vegetation) had been cleared (Burrows and Scanlan 1984). Another estimate based upon visual interpretation of LANDSAT imagery is that 51% of the natural woody cover has been cleared or extensively thinned east of 144° East (roughly a line from Princess Charlotte Bay to Hungerford) (see Map 1). Of those communities classed as forest or woodland in Queensland, some 38% had been cleared prior to 1990 (Govt Qld 1990). In the Roma-Emerald region, about 59% of the area was cleared by 1990 (Smith *et al.* 1994). The Queensland Vegetation and Land Use Monitoring Program being jointly undertaken by Departments of Primary Industries and Lands will provide accurate estimates of the current extent of woody vegetation cover within the State.

There has been no extensive clearing undertaken in Cape York Peninsula, or the Gulf Plains, and only a small proportion of the Desert Uplands and Einasleigh Uplands bioregions has been cleared. The mitchell grasslands are essentially treeless in their natural state. The remaining eastern and southern parts of the State where clearing is widespread, retain about 35% of their tree cover. In the east of the State, these timbered areas are predominantly on rocky or infertile soils (*eg* Ahern *et al.* 1994).

The brigalow (*Acacia harpophylla*), gidgee (*Acacia cambagei*) and softwood scrub communities are the most intensively cleared communities. This is directly related to their high fertility status and due to a government development scheme in the case of the former.

The areas of the State where clearing is most extensive correspond largely to those areas where freehold is the dominant tenure (refer to Map 2).

3.2.3 *Rate of clearing*

The most extensive clearing currently occurring in Queensland is around the northern and western margins of that part of the State already largely cleared, with the northern and north-western parts of the Brigalow Belt and parts of the Desert Uplands being the most affected (DEST 1995).

The actual rate of clearing of woody vegetation in Queensland is unknown but studies are reported in DEST (1995). There are no records available for freehold land, although some studies have included freehold land (Catterall and Kingston 1993) or a mixture of freehold and leasehold (Smith *et al.*1994). The limited area studies that have been done cannot be considered as representative of the State because of the great variation in regional rates of clearing. To remedy this situation, the State has initiated a $7.7 million program which will produce a map of woody vegetation cover as at 1990, and will provide estimates of the annual rate of clearing for the State from 1990 onwards.

A recent analysis of permits granted by Department of Lands in the Central Queensland shires of Jericho and Belyando (DEH 1995) indicates that permits were granted over some 673,000 ha for the period 1990-1995 with 58% being for virgin communities. Records of the area of tree clearing permits in the State over the 12 months of 1994 show that permits were granted for a total of 1.08

million ha (DoL records reported in DEST (1995)). The DEST document incorrectly stated that 63% of the areas under permit were virgin communities - an analysis of actual records is that the correct percentage is 51%. This proportion varies greatly between regions within the State.

The most widely used estimate of the rate of clearing is between 300,000 and 500,000 ha/year as reported in the National Greenhouse Gas Inventory (1994), based on various estimates made by W. H. Burrows (QDPI). A majority of the clearing was considered to be of regrowth rather than virgin communities.

Smith *et al.* (1994) showed that about 14% of a 7.5 million hectare area in a study area between Emerald and Roma had been cleared between 1972 and 1990. This is equivalent to 60,000 ha per year or 0.8% per year.

The extent of clearing in a selected area containing *Acacia* woodlands between Charters Towers and Clermont (part of the northern Brigalow Belt) increased from 5.6% of the study area between 1975 and 1986, to a total of 14.7% of the study area by 1990. This equates to average tree clearing rates of 1,400 ha/year and 6,400 ha/year for the respective periods (Fraser *et al.* 1991).

In a 1400 km^2 coastal area near Brisbane (mainly freehold land), Catterall and Kingston (1993) reported that 33% of all bushland present in 1974 was lost between 1974 and 1989. The current rate of tree clearing on freehold lands is unknown but generally involves relatively small areas as most of the suitable land has already been developed.

3.3 Legislation position

While tree clearing was a necessary part of increasing food and fibre production, trees were also considered a nuisance by many landholders. The extent of clearing was often greater than necessary.

However, there was recognition of the commercial value of timber and penalties were introduced for the illegal destruction of commercial timber. These penalties have existed at least since the 1890s, and they ranged from one shilling to ten shillings per tree.

The *Land Act 1962* requires permits for tree clearing for most leasehold tenures. Although there was increasing emphasis on conservation values, it was not until several major amendments in the early 1990s that real emphasis was placed on sustainability. Sustainability concepts are now embodied in the *Land Act 1994*. (Note that at present, the tree clearing part of the *Land Act 1994* has not been proclaimed. Permits to clear continue to be assessed under the *Land Act 1962*.)

Comprehensive tree clearing controls currently apply only to leasehold and other State lands - about 80% of Queensland is covered by the *Land Act 1994* (see Map 2). Freehold land and freeholding leases are mainly located in the more favoured climatic regions and are not subject to such controls. Some local governments have vegetation control local laws, but these have not been applied to broadscale woodland management. Similarly, conservation orders can be issued on all tenures under the *Nature Conservation Act*, but they are not intended to control broadscale tree clearing.

3.4 Current issues

3.4.1 *Condition of rangeland*

There is ample evidence that the condition and productivity of Queensland's rangelands have declined over time (Mills *et al* 1989, Tothill and Gillies 1992). The deterioration and degradation[5] of pastoral lands is **primarily due to inappropriate land management practices**, rather than a result of tree clearing. For example, de Corte *et al.* (1990) reported extensive soil erosion and increases in woody weeds in a survey area where tree clearing was very limited. Small property size is a contributing factor toward declining land condition (Passmore and Brown 1992). Well-managed clearing within a comprehensive land use planning framework can increase net community benefit provided grazing is well managed.

The ecological processes within the timbered rangelands are poorly understood for most of Queensland's native vegetation communities (Australian Science and Technology Council 1993), particularly the relationship between tree clearing and hydrology, nutrient cycling (Harrington 1990) and native fauna (Recher and Lim 1990).

Changes in pasture composition and other aspects of land degradation are due to various combinations of factors. The following lists some of the more important factors in grazing lands:
- increased grazing pressures from both domestic and non-domestic animals,
- reduced burning,
- provision of stock watering facilities,
- use of bore drains,
- use of feed supplements,
- climatic extremes,
- declining soil fertility status,
- development of salinisation,
- changes in animal types and breeds; and
- indirect factors such as the need to service property debt and maintain cash flows.

A recent assessment of the condition of the more important timbered rangelands in Queensland (Tothill and Gillies 1992) reveals that:

• Black spear grass	some 50% is deteriorating with some 17% degraded
• Poplar box woodland	some 43% is deteriorating with some 19% degraded

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Definition of Land degradation
Land degradation is the decline in condition or quality of land as a consequence of its use by individuals or society (Chisholm and Dumsday, 1987). Land comprises all biological, chemical and physical elements. Degradation has occurred when there is measurable decline from the maximum potential of the land's use, this may affect production as well as conservation values. Generally, it is as a result from the combination of inappropriate land management and land being used beyond its capability.

Land degradation on cleared land is generally associated with stock and pasture management practices rather than with the actual clearing operation. If soil loss and species change does occur within an ecosystem, it is likely to occur irrespective of tree clearing. Degradation also has value-judgements associated with it. For example, the introduction of introduced pastures can pose threats to the integrity of the remnants and corridors of native vegetation intentionally left as part of the tree clearing process, yet from a production focus, they are very productive and highly desirable.

- Gidgee pastures — some 37% is deteriorating with some 32% degraded
- Brigalow pastures — some 37% is deteriorating with some 28% degraded
- Mulga pastures — some 50% is deteriorating with some 30% degraded.

3.4.2 *Loss of biodiversity*

The international significance of the Australian biota and the need for its conservation is widely recognised (Mummery and Hardy 1994). Australia is one of only twelve 'megadiversity' nations (Common and Norton 1992). The ecosystems and processes that support this biota are poorly known, with only about half of Australian species currently named (Biological Diversity Advisory Committee 1992).

In Queensland, there are 924 regional ecosystems identified by Department of Environment and Heritage. Of those, 4% are currently considered endangered, 11% are vulnerable and 14% are of concern (Queensland Department of Environment and Heritage 1995b). Forty-two vertebrate animal species and eighty-one native plants are endangered in Queensland (*Queensland Nature Conservation (Wildlife) Regulation 1994*).

The loss of habitat through tree clearing has the potential to result in further loss of native species. Conservation reserves alone will not maintain biodiversity (Kitching 1994, Taylor 1987). Timbered grasslands are particularly significant for the conservation of nature (Duncan and Jarman 1993, Reid and Fleming 1992).

3.4.3 *Other*

Much of the clearing being done at present is in eucalypt country in sub-coastal and inland areas. In many cases, these are more marginal lands and there is a tendency for greater regrowth to occur, and the soils and climate are such that general levels of pasture production after clearing are lower than in wetter (more coastal) areas. On steeper lands, the risk of erosion is also greater in drier areas because of the lower ground cover.

A major impetus for current woodland clearing is that there has been a general increase in the density of woody plants in many of the woodlands within the State. This increased density has caused increased management difficulties and has resulted in decreased pasture production. Although the lack of fire has been part of the reason for the increased tree density, many woodlands cannot be managed with a burning regime to restore these to a structure that may have existed prior to the establishment of the grazing industries.

3.5 Fire

Most vegetation communities in Queensland experienced regular fires prior to the establishment of a grazing industry, due to lightning strikes and use of fire by aboriginals. Rainforests and some arid community types would have been the exceptions, but even in these cases, fires would have occurred although at a very low frequency.

In grazing lands, the attitude to fire has changed over time and varies with community type:
- In semi-arid areas, the standing fodder is regarded as a 'bank' of forage which can be consumed until the next growth period. This attitude prevails even on those properties which are large enough to allow for a burning regime to be implemented with little risk. There is a reluctance to burn this forage as it could impose 'drought conditions' if rain during the next 'growing season' is minimal. A related concern is that in some areas, once a fire has started, it can be very difficult to

stop. Both these issues are a major factor in the mitchell grass downs communities of western Queensland.

• In tropical parts of the State, where rainfall is more reliable, burning is still a common feature of property management. Pasture growth is rapid and nutrient levels of soils are often low and these combine to produce bulky, low quality feed for stock. Fire removes the large bulk of dry matter and allows easier access to a 'short green pick'.

• In coastal and sub-coastal parts of the State, the attitude to fire has changed considerably since the 1960s. Prior to that period, fire was extensively used to remove dry forage of low quality allowing access to short green pick; to help control ticks; to help keep regrowth in check. With the advent of brahman-infused livestock and supplements, the dry forage became a useable resource and the frequency of burning decreased. A direct consequence of this has been the increase in density and size of native woody species that were previously controlled by the regular burning regimes.

4.0 LAND TENURE

4.1 Essential differences between leasehold and freehold tenures

The tree clearing provisions of the *Land Act 1962* currently apply to all areas except those that are held in freehold title, are freeholding leases (or similar) or are deeds of grant in trust. (As at August 1995, Part 6 of the *Land Act 1994* has not been proclaimed, but will apply to the same tenures).

The essential difference between leasehold and freehold lies in restrictions and obligations on lessees which a freehold landholder does not have. These can be summarised as follows:

• An obligation to exercise a duty of care towards the land (under the *Land Act* 1994);

• An obligation to pay rent to the State;

• An obligation to fulfil lease conditions which may cover a variety of matters from residency to development and improvements. These conditions are usually negotiated with the lessee. Lease conditions are to be reviewed every 10-15 years for new leases under the *Land Act 1994*;

• A restriction on land use in accordance with lease conditions;

• A restriction on land clearing, with a requirement for a tree clearing permit;

• A restriction on transferability applies to certain lease types (*eg* corporations cannot hold grazing homestead perpetual leases);

• A restriction on subdivision that is related to the maintenance of viable property sizes;

• Aggregation controls also apply to certain lease types (*eg* no more than two living areas of grazing homestead perpetual leases can be held by an individual);

• Apart from the above restrictions, leases can be bought and sold. At present there is little differential paid for leasehold land compared with freehold land, despite the fact that various conditions can be imposed on leasehold land;

• A liability to forfeiture of the lease for non-compliance with lease conditions, non- payment of rent or if the lessee acquired the lease by fraud. However forfeiture would only occur in extreme circumstances.

4.2 Current position

The current situation (as at July 1995) is that there are 35936 leases covering 134,725,525ha. There are 7592 grazing leases covering 125,986,233ha and of that area, 15,841,695ha are on freeholding leases.

All grazing leases except those being freeholded are subject to a requirement to obtain a permit to clear trees. Thus about 64% of the State's area is leasehold grazing land subject to a requirement to obtain a permit to clear for broadscale tree clearing. The majority of other lease types (and licences and permits) also require a permit before trees are cleared. While these other leases are large in number (28,344), they occupy a relatively small area within the State (8,739,292ha).

About 19% of the State is freehold or some form of freeholding lease. Other lands occupy about 14% of the State - Reserves (15.59M ha), National Parks (6.218M ha), roads and stock routes (1.5M ha - estimate only) and unallocated State land (302,000 ha).

4.3 Possible trends and their implications

Generally landholders prefer freehold land since this land has the least number of restrictions, particularly in relation to land clearing and subdivision. Changes contained in the *Land Act 1994* (together with other Acts) have caused concerns about security of tenure. The removal of generous freeholding provisions have added to these concerns. The result has been that freeholding may not be an economic option, even though most may wish to freehold their land. Certain policies (especially that dealing with the Location and Degradation Test) make conversion difficult for lands which are susceptible to degradation, are seriously degraded or are significant for environmental protection.

4.4 Multiple use of leasehold land

Since European settlement, Queensland has become a major world exporter of a wide range of primary products. This is a remarkable achievement given the variable climate, paucity of fertile soils, low population density and high costs of transport and materials.

In some regions of the State, the costs of this production includes loss of biodiversity, soil erosion and acute resource limitations related to inappropriate patterns of development and utilisation. A simple example of this is the inevitable decline in native hardwood timber where tree clearing has occurred to improve agricultural and pastoral production without adequate planning to meet future hardwood demands and without appropriate pricing for hardwood timbers. More problematic is the issue of long-term natural resource degradation (*eg* soil loss, water pollution, woody weed encroachment) through poor management practices, particularly in marginal lands.

The challenge confronting land resource managers in Queensland in the 1990s is therefore one of sustainable levels of production and multiple resource utilisation. The term *resource* includes those products of direct human benefit (*eg* shelter, food, water and energy), as well as elements and processes which sustain the viability of the land as an agroecosystem (*eg* the native flora and fauna, both aquatic and terrestrial). This challenge is made more difficult by the complexity of ecological response to change (*eg* threshold effects, time-lags, multiple species interactions) and the vagaries of an uncertain economic future (*eg* fluctuating commodity prices and the cost/price squeeze). In meeting this resource management challenge, State and Local Governments need to consider both public and private interests. Policy is needed that 'leaves no room for exploitative practices that cause lasting environmental damage as the price of short-term profits' (Squires 1990). However, landholders will continue to have the greatest day-to-day management role on grazing lands and must have the economic capacity to manage in a sustainable manner.

Leasehold land in Queensland is used for a variety of purposes depending upon land suitability and socio-economic factors. The major uses include:

- Grazing
    - beef cattle
    - dairying
    - sheep and goats
    - other species (*eg* macropods)
- Cropping
- Timber production
- Mining (coal, minerals, oil and gas)
- Landscaping, horticulture and the wildflower industry (including honey production)
- Conservation of biodiversity (flora and fauna) and geological monuments
- Protection of cultural heritage (aboriginal and non-aboriginal)
- Catchment protection (water quality and quantity, soil erosion)
- Infrastructure (roads, powerlines, communications, etc)
- Tourism and recreation
- Other dedicated purposes (*eg* schools, refuse disposal, etc)

Grazing is by far the most significant land use in terms of area of leasehold land.

5.0 CONSERVATION OF BIOLOGICAL DIVERSITY

5.1 Biological diversity

Biological diversity or biodiversity refers to the variety of life forms: the different plants, animals and micro-organisms, the genes they contain and the ecosystems or assemblages formed. Traditionally, biological diversity is considered at three different levels: genetic diversity, species diversity and ecosystem diversity (Commonwealth of Australia 1993). However as indicated by Noss (1990) and Sattler (1993a) biological diversity should be considered not only in relation to taxonomic distinctiveness but also to environmental and ecological distinctiveness. As such regional landscape is another level at which biodiversity is recognised. The term 'regional landscape' emphasises the spatial complexity of regions. The relevance of landscape structure to biological diversity is now well accepted (Noss 1990).

Human beings are dependent for their sustenance, health, well-being and enjoyment of life on fundamental biological systems and processes. Humanity derives all of its food and many medicines and industrial products from the wild and domesticated components of biological diversity. Biological diversity also underpins and sustains functions important to maintaining a 'healthy' landscape. For example, Ford (1990) and Loyn (1987) have highlighted the role bird fauna plays in maintaining insect populations at levels low enough to prevent defoliation and associated dieback of eucalypts in Northern NSW and Victoria. The value of biological diversity is not restricted to commercially utilised species but also has important social and cultural values (Commonwealth of Australia 1993).

The loss of biological diversity is an emerging international concern (Cooperrider 1990). For Queensland, there are 21 species of flora and 6 vertebrates presumed extinct since european occupation (*Nature Conservation (Wildlife) Regulation Act 1994*). While at present there are 71% of the 924 regional ecosystems recognised[6] in Queensland still relatively abundant in the landscape, 29% of the regional ecosystems are considered as potentially vulnerable and threatened in terms of the degree to which they have been cleared or significantly altered by other land management practices (especially grazing). Of these, 4% are classified as endangered (Queensland Department of Environment and Heritage *in prep.*).

Conservation reserves contain about 2.1 Million ha of forests and woodlands (DEH submission to National Forest Inventory State of the Forests Report 1995). However, conservation of endangered elements and the natural biodiversity is dependant not only upon the habitat contained within the boundaries of a protected area but upon the landscape context in which each reserve exists. Protected areas are parts of a still larger system. The reserve system established in Queensland is the principal tool for protection of biodiversity but this approach cannot achieve the objective in totality and satisfy Queensland's commitment to the National Strategy for Ecologically Sustainable Development (1992). A complementary approach is to facilitate proactive management of other lands to protect their biodiversity. This may be achieved through voluntary conservation agreements, lease conditions (of new leases) and other arrangements with landholders. Conservation of savanna lands will require both adequate care of land in the pastoral estate and the establishment of a rationally designed reserve network (Woinarski 1993).

5.2 Strategies for Conservation of Biodiversity

Strategies for the conservation of biodiversity are closely aligned with the levels at which biodiversity is recognised (see section 5.1). Species are classified into 'Rare' and 'Threatened' (*Nature Conservation Act 1992*) or other status classes (*eg* Dickman *et al.* 1993) according to their extent and threats to survival. These species and appropriate management options may then be prioritised and addressed on a case by case basis, often through the 'Species Recovery Process' (Reville 1992). The management of these and other species with particular management requirements or commercial uses (*eg* macropods, crocodiles, waterfowl) can also be addressed by the preparation and implementation of Conservation Plans under the Queensland *Nature Conservation Act 1992*.

It is widely recognised that species will not be adequately protected without conserving their associated habitat (*eg* Queensland *Nature Conservation Act 1992*, ANZECC 1993, Anon 1995) and that strategies aimed at the species level are too expensive to apply other than to the most threatened or necessary cases. Therefore, conservation strategies need to place a heavy emphasis on the protection and management of 'ecosystems' (or land types or habitats). Methods for defining

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[6] These ecosystems were identified for conservation purposes and are not necessarily an appropriate basis for developing tree clearing guidelines.

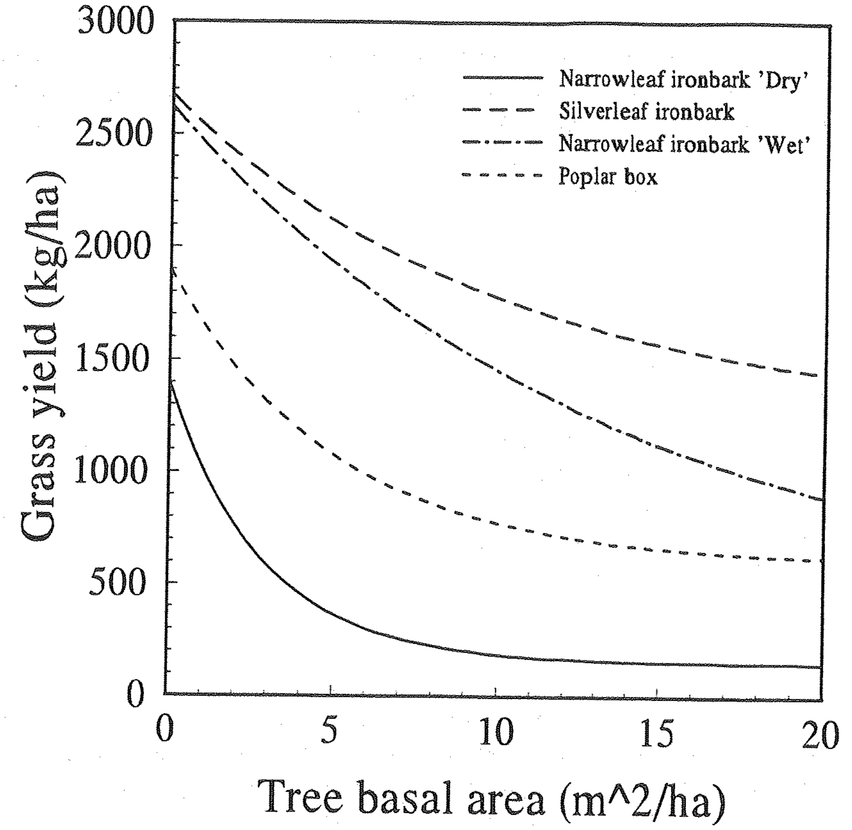


Figure 1. Relationship between tree basal area and grass yield in eucalypt woodlands of central Queensland (based on Scanlan and Burrows 1990).

ecosystems do vary depending on the available data for the area of concern, but always involve some kind of biological classification scheme. Classifications used for conservation in Australia often are based on different vegetation, or land system mapping (*eg* Pressey 1994, Pressey *et al.* 1993) or some kind of 'domain' analysis where areas are grouped by numerical classification of geology, climate and landform (Mackey *et al.* 1989, Young and Cotterell 1993). The conservation and management of ecosystems from across their ecological and geographical range is often used as a surrogate measure of the conservation of species and within-species variation (Thackway and Cresswell 1995).

Conservation strategies at the landscape level recognise that management of a site must take into account influences and management of the surrounding area or region (Saunders and Curry 1990). Strategies at this level address factors such as the relationship between fragments through corridors and riparian areas and with other remnants. Some of these factors are addressed in sections 10.2 and 10.3 of this document.

Despite all efforts, a reserve-based strategy will not be sufficient to conserve biodiversity in general and for birds in particular (Recher and Lim 1990, Nix 1993, Kitching 1994). According to Nix, the introduction of the exotic grazing animal has been a principal cause of bird decline. Queensland contains a very high diversity of avian habitats (Taplin *et al.* 1993). These very diverse habitats collectively support about 90% of all Australian bird species (Nix 1993). Unfortunately the State contains a substantial number of rare and threatened species and is the only State in mainland Australian in which a bird species has apparently become extinct since european occupation of the continent (Taplin *et al.* 1993).

Livestock and feral animals have the same requirements as native species and in time of drought heavy pressures are placed on riparian zones, remnants and corridors of native vegetation. What is required in terms of vegetation retention is a balance between production and conservation. Intelligent and sympathetic integration of conservation and productive land uses can benefit landholders, the wider community and wildlife (Harrington 1990, Nix 1993).

6.0 DEVELOPMENT FOR PRODUCTION

6.1 Production relationships

There are about 60 Million ha of grazed woodland communities in Queensland out of a total State area of 173 M ha. (There are also about 16M ha of national parks, State forests and timber reserves which support moderate to dense woodland or forest cover). Apart from mulga, the woody dominants in these communities are largely unpalatable to domestic stock.

There is considerable anecdotal (Royal Commission 1901, Inter-Departmental Committee 1969, Rolls 1981, Allingham 1989, Joyce 1990, Simpson 1992, Tothill and Gillies 1992, Harland 1993, Reynolds and Carter 1993) and empirical evidence (Burrows *et al.* 1985, Burrows 1995) that woody plants have increased in both density and biomass under grazing in Northern Australia since european settlement. These observations and measurements are backed up by ecological theory (Westoby *et al.* 1989, Tropical Grasslands 1994) which draws heavily on Australian and Queensland woodland examples for its support.

Non-leguminous trees and shrubs normally decrease pasture production within their projected tree canopies and beyond. Documentation of decreased pasture production in woodlands of Queensland include *Eucalyptus crebra* in north Queensland (Gillard 1979, Gardener *et al.* 1990); *Eucalyptus* spp. in central Queensland (Walker *et al.* 1986, Scanlan and Burrows 1990); *Acacia harpophylla* in central Queensland (Scanlan 1991); *Eucalyptus populnea* (Walker *et al.* 1972) and *Callitris columellaris* (Wells 1974) in southern Queensland; and *Acacia aneura* (Beale 1973) in south-western Queensland. Moisture competition is the most often cited reason for reduced growth of pastures within woodlands, and therefore Mott and Tothill (1984) suggest that trees will have relatively less effect in areas where there are fewer dry periods (soil water stress conditions) during the growing season. Recent simulations (Scanlan and McKeon 1993) have indicated that rainfall distribution and soil depth have a large impact on the degree of competition between pastures and trees.

Several important situations exist where trees have been reported as improving pasture growth. Christie (1975) noted that only 6% of an area was covered by the canopies of *Eucalyptus populnea* in central-western Queensland, but that this area produced about one quarter of the total pasture growth if sown to buffel grass. Lowry (1989) also noted increased growth beneath *Ziziphus mauritiana* in north Queensland, while Cameron *et al.* (1989) claimed no effect of young *Eucalyptus grandis* trees soon after establishment on growth of *Setaria*-based pasture.

Detailed field experiments in the Charleville (Beale 1973), Dirranbandi (Walker *et al.* 1972), Mundubbera (Tothill 1983), Gympie (Walker *et al.* 1986), Dingo (Scanlan and Burrows 1990) and Charters Towers (McIvor and Gardener 1995) districts have conclusively demonstrated that pasture production is improved from 2 - 4 times when woody plant competition is removed from our grazing lands (*eg* Fig. 1). Stock carrying capacity on treated areas improves proportionately and the increased pasture gives the landholder the flexibility to lower overall property grazing pressure and so improve individual animal performance. Increases of 2-3 fold are recorded in cattle liveweight gain per hectare from removing *Eucalyptus* spp. competition (Tothill 1983, Rae 1989).

The extra pasture also lowers the risk of soil erosion, provided the overall utilisation levels (pasture eaten as a proportion of pasture grown) are reduced. Where woody plant competition is reduced there are also greater opportunities to introduce improved pasture species. Thus clearing may increase livestock numbers per unit area but decrease the impact of those animals on the herbaceous vegetation. Native pasture systems in northern Australia augmented with legume (mainly *Stylosanthes*) are not stable when stocking rates are increased substantially (Mott and Tothill 1984). Gillard *et al.* (1989) suggested that the augmentation of native pasture with the introduced legume *Stylosanthes* was likely to produce greater financial gains than tree clearing in north Queensland.

The relative decrease in production is greatest in semi-arid regions where a tree basal area of only 1 m^2/ha reduced pasture yields by 50% (Beale 1973). This contrasts with central Queensland where a reduction of 50% occurred at 5 to 15 m^2/ha, depending on fertility (Scanlan and Burrows 1990, Walker *et al.* 1986). In the tropics soil fertility is relatively low, soil moisture availability during the growing period is generally high and the tree density is generally lower than in southern parts of the State. Under these circumstances, trees may have less effect on pasture production (Mott and Tothill 1984). However, effects of trees on pasture production are still expected, based on simulation studies (Scanlan and McKeon 1993). McIvor and Gardener (1995) reported large increases in pasture production on fertile clay soils in north Queensland.

Apart from increased animal production, advantages from clearing woodlands may include: lower overall grazing pressure (lower stock numbers per unit of forage produced); improved livestock handling; improved ground-water supplies; better dietary choice and improved habitat for some wildlife (*eg* grazers cf. browsers); oversowing of the resulting pasture with legumes (*eg* seca stylo) may also be enhanced. Clearing allows tree species with undesirable characteristics for grazing (*eg* unpalatable leaves) to be replaced by useful fodder trees (*eg Leucaena*).

Most of the benefits and problems arising from reducing woody plant competition with pasture in grazing lands have been addressed in a comprehensive review by Burrows (1993). The production and economic benefits to graziers of responsible and sensible management of woody plant populations are quite substantial over most of Queensland, especially in southern and central parts of the State. These benefits are easily and convincingly demonstrated (see Fig. 2) by comparing woody plant management options using the GRASSMAN decision support package (Scanlan and McKeon 1990). There are obvious financial benefits arising from applying woodland management and woody weed control as evidenced by the observation that these practices are almost universally implemented throughout the grazing lands.

The use of shelter strips in cropping systems is uncommon in Queensland, and observations indicate that native vegetation on the margins of cropped areas generally decreases crop height and presumably yield around the perimeter of the cropped areas. Kohli *et al.* (1990) indicate that shelterbelts of 8-year old *Eucalyptus tereticornis* trees in India can reduce crop yield for a distance of 10m from the belt. By contrast, livestock and crop production can be increased by using remnant vegetation for shade and shelter in some environments. In the temperate climates of southern States, wool production was increased by 31%, and pasture and crop yields by up to 30% in a downwind zone extending about ten times windbreak height (Breckwoldt 1986, Bird 1984). This has not been demonstrated in the tropics.

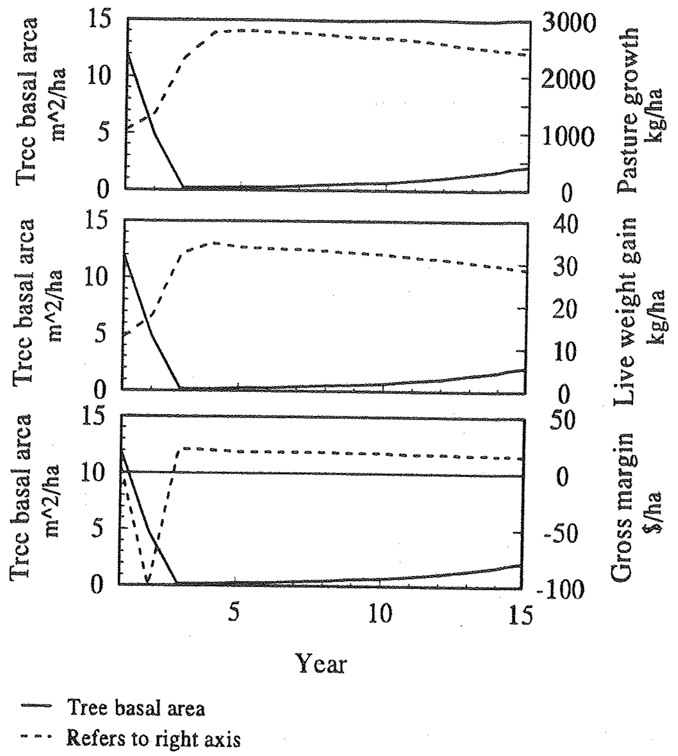


Figure 2a Responses to Graslan® treatment of a poplar box community on a loamy soil at Dingo under average rainfall conditions (using GRASSMAN - Scanlan and McKeon 1990).

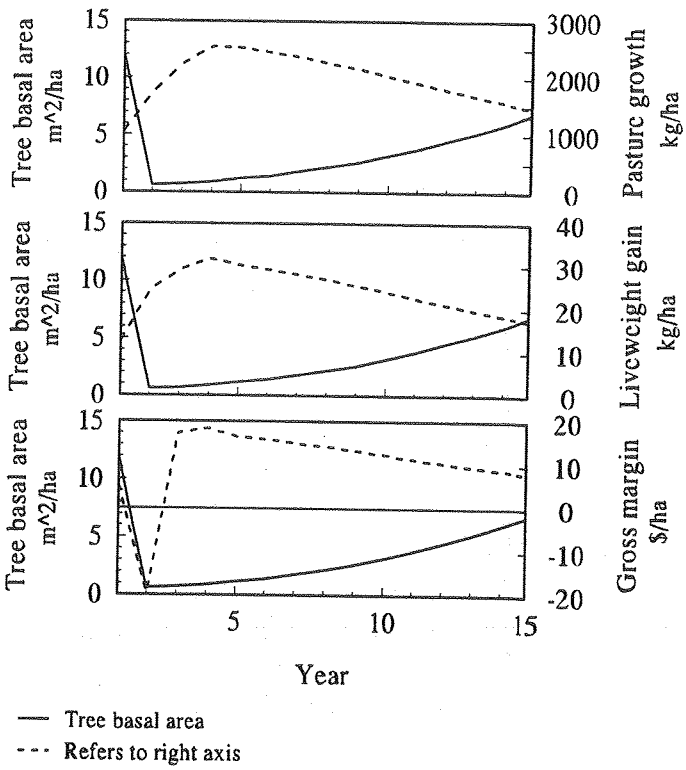


Figure 2b Response to Tordon® treatment of a poplar box community on a loamy soil at Dingo under average rainfall conditions (using GRASSMAN - Scanlan and McKeon 1990).

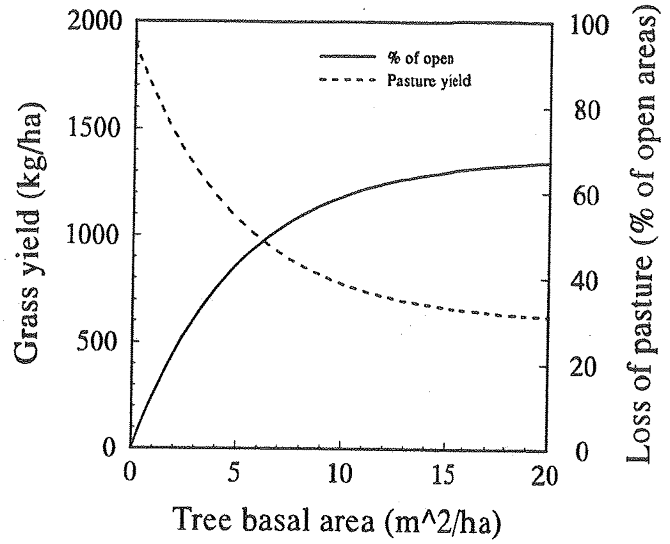


Figure 3 Tree grass relationships in mature woodlands in central Queensland. Data for poplar box from Scanlan and McKeon (1990).

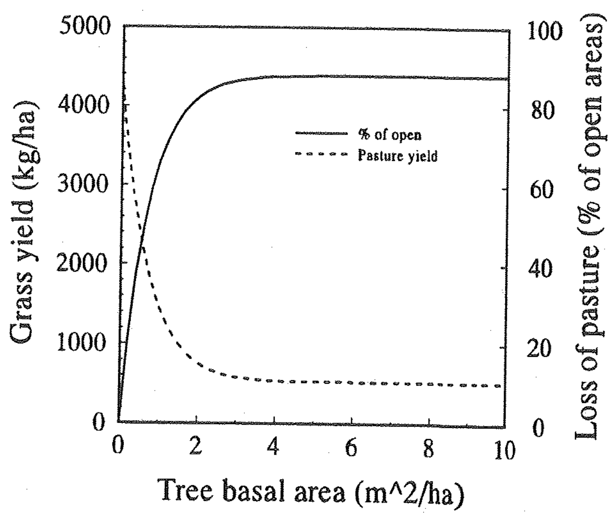


Figure 4 Tree-grass relationships in brigalow regrowth on a clay-loam surfaced duplex near Theodore, Queensland. Data from Scanlan (1991).

6.2 Regrowth management

The method of clearing and the regenerative mechanisms of woody plants will influence the consequences of clearing.

Within the *Acacia harpophylla* communities, most species are vegetative reproducers, and the most common method of initial clearing is to pull a chain between two bulldozers. This snaps most plants off at ground level (unless the soil is very moist) and the majority of original plants regenerate from root suckers or broken-off stumps. If the initial clearing includes a ploughing operation which kills most of the original plants, then there is little regeneration in the future as propagation from seed is uncommon among these woody plants.

Within the *Eucalyptus* spp. communities, a common method of tree treatment is to kill individual trees with stem injection of a picloram-based aboricide. This allows for selective treatment and retention of desirable trees. Also the understorey population of seedlings and multi-stemmed suckers is left untouched. Under these circumstances, there is considerable growth of these suppressed plants. This may require a follow-up treatment on a regular (10-15 year) basis to maintain pasture production (Burrows *et al.* 1988a).

Another option in the above cases is to use a residual herbicide (principally tebuthiuron) that is applied to the soil surface, usually from the air. This has the advantage of being rapid to apply and also it potentially affects all plants in the treated area. This means that better planning can be undertaken as it is known that the treatment will be effective (unless the few resistant plant genera are important components - notably some *Acacia* spp. and *Eremophila* spp.), enabling the retention of a desirable configuration of the original vegetation.

The mulga lands of south-western Queensland are a case where the major disturbance has been grazing, mainly by sheep with some cattle, and a period of rabbit infestation. These conditions alone have resulted in a landscape that is becoming increasingly dominated by understorey shrubs (Burrows *et al.* 1985).

Any increase in woody plant density and biomass in woodlands is potentially detrimental in pastoral production terms. This increase can arise from (i) 'disturbance' to the ground layer in uncleared woodlands, leading to an increased density ('thickening up') of existing populations (ii) regeneration from seedlings and/or root suckers, following mechanical or chemical control of overstorey plants and (iii) invasion of existing areas by native or exotic species which did not occur there naturally. Such increases in woody plant cover alters the structure and functioning of ecosystems, for both production and conservation.

Burrows (1995) reported tree basal area growth increments of 0.135±0.062 m^2/ha/yr (mean of 24 diverse sites) for eucalypt species in Queensland's grazed woodlands over a 10 year period from the early 1980s. These figures are supported by similar trends observed by Queensland Forest Service staff in "intact" native forest areas. For the five year period 1989-1994 a clearing strategies trial in a poplar box community at Dingo (MRC-project DAQ.094) recorded mean basal area increments of 0.117 m^2/ha/yr (plot where all trees were treated with hexazinone), 0.170 m^2/ha/yr (plot treated with picloram leaving 20% mature trees scattered), 0.457 m^2/ha/yr (plot pulled with chain and bulldozer) and 0.07 m^2/ha/yr (plot pulled and subsequently burnt). Quantitative data are also available for brigalow regrowth rates (Scanlan 1984) and *Acacia nilotica* invasion of mitchell grasslands (J Carter unpublished).

Average basal area growth rates of 0.135 m^2/ha/yr in intact eucalypt woodlands would have little additional depressant effect on understorey pasture production as it is already greatly reduced by mature tree competition (see Fig. 1 for greater than 10 m^2/ha). Conversely regrowth rates following tractor pulling (0.46 m^2/ha/yr for poplar box) can reduce pasture production by 50% within 11 years (Fig.3). Regrowth following stem injection (retaining 20% of box trees scattered over the paddock) would reduce pasture production by 28% over the same time frame. Untreated brigalow suckers can reduce pasture production to negligible amounts within 5 years of pulling when tree basal area approaches 2m^2/ha (Scanlan 1984 - Fig. 4).

7.0 TREE RETENTION AND ECOLOGICALLY SUSTAINABLE DEVELOPMENT

7.1 What is 'Ecologically Sustainable Development'?

Resource and environmental issues are being increasingly considered within the emerging framework of sustainability, despite the difficulty of translating general concerns in a manner useful to a particular task (Dovers and Norton 1994).

The Brundtland Report (of the World Commission on Environment and Development, 1987), in outlining how governments may achieve the objectives of economic development and environmental protection, provided an early interpretation of sustainability as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'.

This definition was then refined for the National Strategy for Ecologically Sustainable Development (endorsed by the Queensland Government in 1992) as 'using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained and the total quality of life, now and in the future, can be increased'.

The core objectives of ecologically sustainable development are:

- to enhance individual and community well-being and welfare by following a path of economic development that safeguards the welfare of future generations;

- to provide for equity within and between generations;

- to protect biological diversity and maintain essential ecological processes and life-support systems.

The guiding principles are:

- decision making processes should effectively integrate both long and short-term economic, environmental, social and equity considerations;

- where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation;

- the global dimension of environmental impacts of actions and policies should be recognised and considered;

- the need to develop a strong, growing and diversified economy which can enhance the capacity for environmental protection should be recognised;

- the need to maintain and enhance international competitiveness in an environmentally sound manner should be recognised;

- cost effectiveness and flexible policy instruments should be adopted, such as improved valuation, pricing and incentive mechanisms; and

- decisions and actions should provide for broad community involvement on issues which affect them.

These guiding principles and core objectives need to be considered as a package. No objective or principle should predominate over the others. A balanced approach is required that takes into account all these objectives and principles to pursue the goal of ESD.

In the context of the grazing ecosystem, sustainability would require use to take place in an ecologically conservative fashion, within apparently safe limits that have been determined by an integrated assessment of current and potential threats (Dovers and Norton 1994). In the absence of sufficient ecological information, sustainability includes the adoption of the precautionary approach to environmental issues. (The precautionary principle requires that if the full impact of a decision is unknown and the consequences of that decision are irreversible, then that decision should not be made.)

7.1.1 *State legislation*

Today's environmentally-aware society demands better management and protection of natural resources while meeting the publicly desired goals of economic development. The *Land Act 1994* and the *Rural Land Protection Act 1985* and their supporting policies and procedures are suitable mechanisms for delivering ESD objectives, both independently and in conjunction with environmental, conservation, natural resource and planning legislation.

The objectives of ESD and resource sustainability may be met through a combination of ecological land management and the land tenure system. The leasehold tenure system remains one of the most simple and direct tools to achieve Government policy and to protect the wider public interest.

It must be emphasised that land resource sustainability and associated economic viability of land-based enterprises is not the sole responsibility of any one department, but a goal which should be addressed comprehensively and holistically, across government.

As the custodian of the State's land assets, the Department of Lands has a statutory responsibility to protect, maintain and enhance those leasehold lands through policy, planning, and administration areas. Yet, Government cannot oversee the day-to-day management of leasehold land. Where property viability is perceived to be threatened (whether by market changes or by increased levels of regulation), historical evidence suggests that the resource will be over-utilised in an attempt to survive economically. Thus, Government policy should consider the potential impact of changes that may influence the actual or perceived viability of landholders.

7.1.2 *Implications for land managers*

While recognising that primary responsibility for undertaking sustainable land management of State land lies with the lessee or manager, ultimate responsibility for the sustainable land use and management lies with Government, acting in the public interest.

Land managers of State lands are expected to exercise a duty of care towards lands under their custodianship, and land management practices, including tree management, are one facet of this responsibility.

Regional and local tree clearing guidelines provide a legislative means for the State to meet its policy objectives regarding sustainability, while enabling local environments and producer experience to be accommodated. These guidelines should reflect the inherent biological and physical features of each land type which determine the resilience of the ecosystem (Holling 1986) and which define its role in the functioning of the local and regional landscape (Noss 1983, Hobbs 1993).

7.2 Benefits of retaining native vegetation

Benefits from retaining native vegetation clearly fall into two categories - measurable shorter term economic benefits to the landholder and desirable medium to long-term benefits that are not easily measured, or impact beyond the farm gate.

7.2.1 *Economic benefits to producers*

There has been little systematic research into the benefits of shade and shelter for agriculture and pastoralism in Queensland. Unlike southern States of Australia, where past overclearing has led to a greater appreciation of the role of trees in the farm landscape (*eg* Hofler 1984), the focus in Queensland has been largely on the means of clearing vegetation and controlling regrowth, while minimising soil degradation (*eg* Scanlan 1988).

7.2.1.1 *Shade.* Despite the introduction of heat tolerant cattle, most landholders see tree retention desirable at least for stock shade and shelter. Shade may enable cattle to graze longer during the day and may extend the usage to areas well away from watering points. At least half the calf losses in north-western Queensland can be accounted for by heat stress, particularly in the first week of life and in calves born away from shade. Heat stress also reduces fertility (Daly 1984).

The lack of shade is a cause of increased lamb mortality in the naturally treeless, mitchell grasslands of north-western Queensland. Increases of up to 20% in lamb marking percentages have been reported by the provision of shade during the last weeks of pregnancy and during the lambing period (Roberts 1984).

In southern Australia, livestock and crop production can be increased where remnant vegetation acts as a windbreak and provides shade, and costs on replanting in the future can be saved (Breckwoldt 1986). This has not been demonstrated in the tropics.

7.2.1.2 *Shelter.* Shelter from strong, cold winds is a consideration in parts of southern Queensland especially for newly shorn sheep. High value horticultural crops may also require some form of protection from wind, but this is usually provide by planted windbreaks, rather than natural vegetation.

In northern New South Wales, wool production was increased by up to 31% and sheep were on average 6 kilograms a head heavier, when protected by an efficient wind break. Survival rates of lambs and sheep were also higher during extreme conditions (Bird *et al.* 1984).

In areas prone to frosting, tree clearing has been shown to lead to minimum temperatures 2-4^{0}C colder, and herbage remained green when all herbage in cleared areas had been frosted (McIvor 1989).

In southern Australia, shelter belts, while reducing crop yields adjacent to the tree line, can lead to increases in production to a distance of up to 25 tree heights, due to moisture savings, higher CO_2, higher soil temperature and less wind damage (Bird 1984). This has not been demonstrated in the tropics.

7.2.1.3 *Topfeed.* Retention of native vegetation for the provision of fodder production from trees/shrubs is often quoted as an example of good management practices. In Queensland, this applies primarily to the mulga country (*Acacia aneura*) as mulga leaf is an important dietary component under all conditions, and is extensively used for drought feeding.

However, this has a downside in that it enables stock to be retained in paddocks long after the herbaceous species have been severely grazed. Many grasses are resistant to grazing during the dormant period, but it is during the initial growth phase after rain that the presence of high stock numbers can result in severe damage to regrowing pasture plants (Harrington *et al.* 1984).

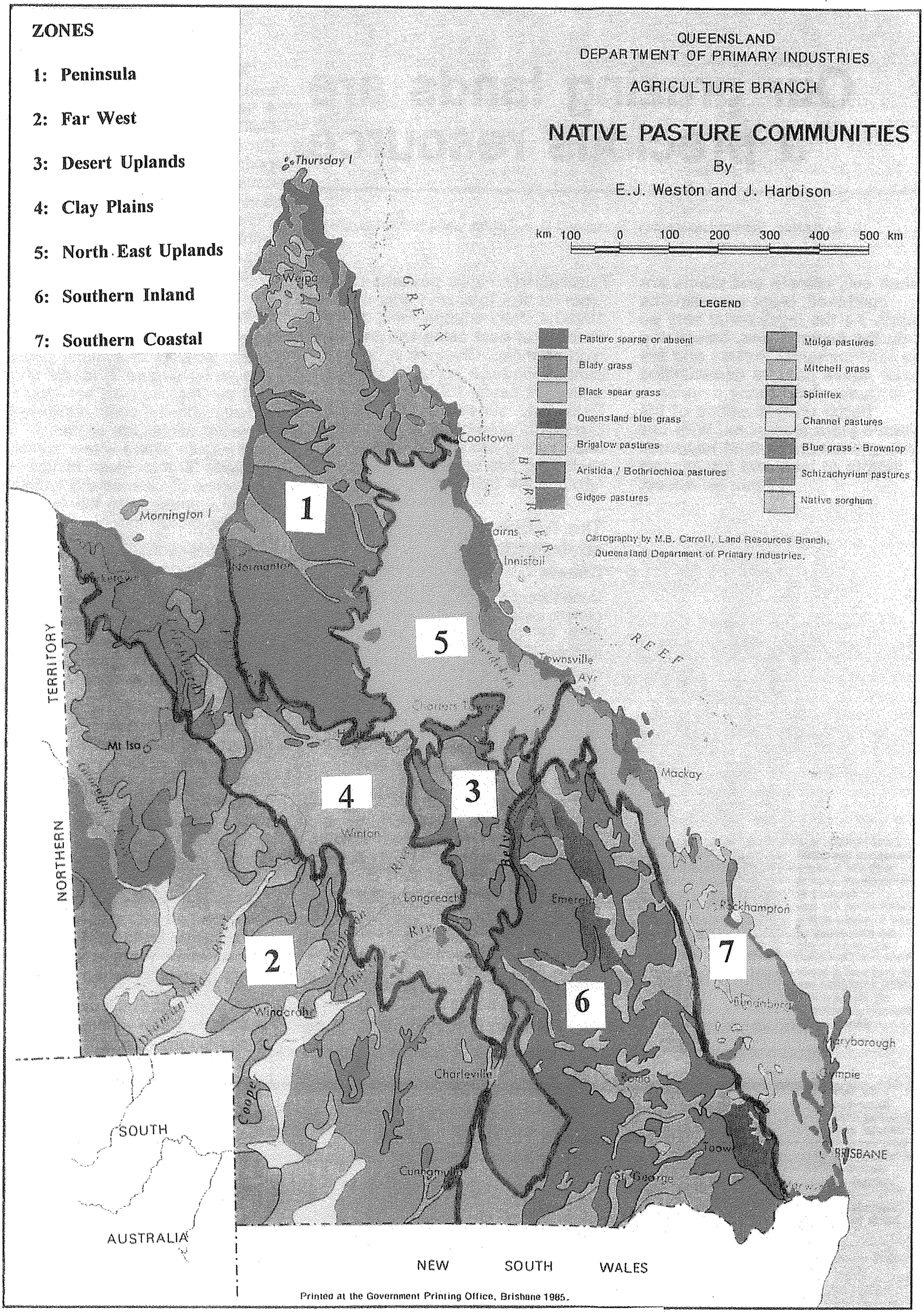
7.2.1.4 *Timber.* Maintenance of a supply of useable timber is a concern to many grazing properties in Queensland, although the concern is inversely proportional to the amount of remaining natural vegetation. Many millions of tonnes of timber were simply burned during the brigalow development scheme in central Queensland, because at the time there was no commercial use for that timber. The same situation exists with much of the clearing of eucalypt woodlands at present.

7.2.2 *Benefits to society*

Many desirable aspects of retaining natural vegetation revolve around benefits to the whole of society. In an environment of economic survival, many landholders are forced into making individual decisions that may be beneficial (essential) to them in the short-term but which are disadvantageous to the wider community in the longer-term. Salting from clearing land on water intake areas and causing rising watertables is an extreme example in this regard. However, landholders recognise that these major impacts cannot be allowed to occur.

The maintenance of species diversity (flora and fauna) achieved by retaining native vegetation is highly desirable for the community and is an essential element of State and national obligations. In many cases, landholders consider that this has limited direct benefit for the individual, and in fact, it may reduce potential agricultural or grazing productivity. Thus there is little incentive to manage lands for biodiversity purposes, especially if there is an associated negative impact on production or management. However, some grazing companies are effectively working with conservation agencies in a cooperative, mutually beneficial manner (Wim Burggraaf - keynote presentation at Katherine Rangeland Conference 1994).

Specifically in relation to tree clearing on leasehold land, some landholders argue that if they are required to retain trees for community benefit, then this should be accompanied by compensation in some form.



Map 3 Tree clearing zones as referred to in Draft State Guidelines.

7.3 Degradation and clearing

Tothill and Gillies (1992) define sustainability in grazing lands as the long-term maintenance of the livestock production resources and environment to enable viable livestock production. Degradation represents an undesirable change from sustainability and is considered at two levels - deteriorating and degraded. Deteriorating states are considered to be readily reversible through improved property management and/or following a return to years of average or above-average rainfall. A degraded state occurs where the system can not be brought back to an acceptable condition with changed management only. The inputs necessary are generally outside the bound of economic management, or it cannot be done at all.

Tree or woodland clearing *per se* generally does not contribute to degradation in the terms described above. Situations where clearing would be expected to lead to degradation are excluded under current provisions of the *Land Act 1962* and would be included in any guidelines (*eg* areas too steep or liable to lead to salt outbreaks, areas of high conservation value). Burrows (1993) has observed that degradation generally results from poor pre-clearing planning or post-clearing management rather than the clearing operation *per se*.

In grazing management terms three things are said to damage pastures: overgrazing, regular overgrazing and continuous overgrazing (Miller *et al.* 1991). Hence it is possible to have degraded pastures where the trees are intact (*eg* many parts of the Burdekin River catchment and mulga lands) or where trees have been completely removed or never existed (*eg* frontages in parts of the Warrego and Paroo River systems).

Because woody plants can compete so strongly with understorey pasture (see Section 6) the removal of this competition can boost pasture production substantially on treated areas. This in turn can help to reduce or dissipate grazing effects on the remaining grazing land. Where ground layer production or cover is poor, this is more likely due to the presence of high levels of woody plant competition rather than due to the absence of trees, keeping in mind the overriding influences of soils, climate and stocking rate.

The loss of habitat is undoubtedly the most significant single threat to the survival of particular species and to the State's overall biodiversity. Native vegetation clearance has been very extensive in particular ecosystems and ecological communities. However, it should be noted that tree clearing is not the only contributor to loss of biological diversity - overgrazing has been widely recognised as an important factor (Foran *et al.* 1990; Morton and Price 1994). The savannas are also being seriously threatened by exotic weed species, some of which were deliberately introduced by pastoralists (Scanlan 1986, Australian National Parks and Wildlife Service 1990).

7.4 Greenhouse effect

This important issue is currently the subject of research in many areas. The possible impacts on rangelands has been addressed in a recent workshop (Stafford Smith *et al* 1994). Conclusions from this workshop included that there will be a tendency for increased woody plant cover, and an increase in runoff associated with increased intensity of rainfall events.

The impacts of increased levels of greenhouse gases and climate change are likely to be widespread and cause fundamental changes to basic ecological processes. This will bring about changes in management, whether land be used for agricultural production or for conservation purposes. Hughes and Westoby (1994) have considered some of the effects of climate change on conservation.

7.4.1 CO_2 *emissions from grazing land*

The National Greenhouse Gas Inventory for 1990 concluded that net anthropogenic emissions of CO_2 from the land use change and forestry category amounted to 131 Mt or 31% of total CO_2 emissions in Australia (National Greenhouse Gas Inventory Committee 1994). However Burrows (1995) has argued that instead of agricultural land use being a net emitter as the inventory proposes, this sector is actually a very positive sink. This latter position has now been supported by Prof. Graham Farquhar (personal communication) who chaired the Land Use Change and Forestry Workbook #4 for the 1990 Inventory.

Evidence that the increased woody plant biomass in the grazed woodlands is of anthropogenic origin has been detailed in the 'Production Relationships' Section, where anecdotal and empirical support, as well as emerging ecological theory have all been invoked.

Including growth estimates for Queensland's grazed woodlands (Burrows 1995) in Australia's 1990 Greenhouse Gas Inventory would have reduced the net emission figure from all sources (572 Mt CO_2 equivalent/yr) by 130 Mt CO_2 per annum or 23%. Potential deficiencies in this estimate include: the exclusion of non-eucalypt woody species; the exclusion of native and exotic tree/shrub invasion of mitchell grasslands *inter alia*; and the non documentation of similar woody plant density/growth increments in north western NSW and the NT. This makes it possible that Australia's net emission figure may have been overstated by up to 200Mt CO_2 equivalent per year. (To put this in perspective, schemes proposed by Senator Faulkner and Mr McLachlan earlier this year aimed to reduce greenhouse gas emissions by c. 28 Mt or 'fix' a total of 15Mt of greenhouse gases over a period of 5 years respectively).

Unfortunately the anthropogenically induced sequestration of carbon in Queensland's grazed woodlands was omitted from Australia's 1990 Greenhouse Gas Inventory. Consequently this has had a misleading and detrimental impact on the way agricultural land use is now viewed in 'Greenhouse' terms in Australia, especially from a Queensland perspective. In addition, Australia's per capita net emissions have been made to appear far worse than they actually are and this has not helped our stance on the world 'Greenhouse Stage'.

8.0 RURAL SOCIAL ISSUES

8.1 The Draft State Guidelines and property values and equity

The impact of the Draft State Guidelines for Tree Clearing on rural property values is difficult to accurately gauge due to the limited sales evidence of affected properties. (See Map 3 for Zones used in Draft State Guidelines). However, the available evidence indicates that there is an economic impact.

There is total disinterest in the marketplace for properties in Central Queensland which are only partially developed and have potential for further development. From the available sales evidence, it is concluded that the Draft State Guidelines have affected property values of undeveloped or lightly developed properties; ranging from a best case scenario of 15% discount to the market to a worst case of 70% discount (see Appendix 3 for detailed analysis of some property sales in Central Queensland).

However, perhaps the more serious result of the Draft State Guidelines, is the fact that undeveloped properties are now virtually unsaleable.

8.1.2 *Developed properties*

Observations are that the guidelines will have no effect on the value of fully developed properties, where the only timber treatment required is the control of regrowth.

Sales of various properties and marketing agents reveal that any impositions placed on the treatment of regrowth only comply with good management practices and in some cases adherence to such practices may in fact increase the value of the property.

This assumes that regrowth is defined as a result of previous development and that no unreasonable interpretation is made in relation to height /size of regrowth, otherwise there would be a similar effect on market values as evident for undeveloped land.

8.1.3 *The effects on equity*

Major financial institutions or lenders are eagerly awaiting the successful conclusion of the development of local guidelines for broadscale tree clearing. They are concerned that if the general provisions of the Draft State Guidelines are mirrored in local guidelines, this will dramatically decrease equity levels. They have indicated their intentions in relation to financing of properties where the guidelines will have effect, as evidenced by the decision of one institution to withdraw approval for finance on a property.

8.1.4 *Conclusions*

While this assessment is based on trends within Central Queensland up till July 1995, it is considered that similar reductions in the market value of property values will be reflected in other regions also, particularly for undeveloped or partially developed leasehold properties. The number of affected properties would be significant on a State-wide basis.

The effects on undeveloped and partially developed properties are the most significant with a reduction in value between 15% and 70%. Also of real concern is the fact that these properties are virtually unsaleable. Adjustments in the values of fully developed properties are not noticeable.

The Draft State Guidelines will have no effect on *current income* but rather restrictions may effect future income (if regrowth treatment is prevented) or reduce potential for increased future income (by preventing development).

The attitude of financial institutions to the equity value of leasehold lands is a 'wait and see' approach.

8.2 The effect on rural confidence, rural communities and adjustment.

Tree clearing on rural lands is an emotive issue for rural producers and the community as a whole. The maintenance of trees and forests form an important part of the environmental ethos of the Australian community. At the same time the management of tree cover is a critical component of the business planning for rural producers.

Overall, rural producers try to manage their properties in an environmentally sustainable manner. They have come to realise that many former practices may not be sustainable in the long term and are detrimental to long term financial performance. However, in many areas of the State over the last few years, rural producers have been struggling against factors such as drought, low commodity prices and high interest rates, and as a result, short term survival has sometimes taken precedence over long term sustainability.

Farmers and graziers generally recognise the need for community-driven guidelines which promote sustainable management practices in areas such as tree clearing. However a fundamental prerequisite for rural producers is a stable and clear policy environment from government. Without this, business generally and the rural sector in particular (because of relatively higher risk) is unable to manage investment and plan for the future.

The Government's policy of consultation on major issues affecting rural communities has been a key factor in building confidence within the primary industry sector. When communities perceive that the consultation process has broken down, as in the recent development of Draft State Guidelines, they lose that confidence in Government. This leads to suspicion of Government as a whole and unfortunately can lead to rejection of other Government initiatives which are unrelated to the issue under debate. This has already happened in South West Queensland, where producers who had initially shown enthusiasm for the adjustment objectives of the South West Queensland Strategy, are now backing away from it until the tree clearing issue is resolved.

Government policies also impact on producers' impression of their capacity to make long term business decisions. This can lead to a 'capital strike', a rundown in farm capital, reduced efficiency and output. This in turn leads to the adoption of less sustainable farming practices as producers attempt to generate increased income from the existing capital stock.

Perceptions about the likely impact of tree clearing on farm viability, whether real or not, can have a detrimental effect on business confidence and decision making in the rural community. It can reduce the willingness and/or the ability of rural producers to take what was before a reasonable risk. Until there is a better understanding of and agreement to the tree clearing guidelines by the rural community, producers will question their ability to make land management decisions in the future.

The rural financial institutions also become concerned, which could cause them to withdraw financial support, or at least make finance more difficult to obtain. This is likely to reduce the enterprise's ability to repay debts and support the family. This in turn has implications for the rural community in terms of a direct decline in demand for locally supplied goods as producers cut back on expenditures on a range of capital and consumer goods. Families will have less cash for essential services such as education and non government health care, increasing the need for social welfare support as financial and emotional stress increases.

In areas where debt levels are high, producers are suffering from drought, or where the community is trying to encourage the adjustment of small uneconomic enterprises, any increased caution by finance providers can cause additional stress within the community. Marginal or uneconomic enterprises will be pushed harder to either produce or adjust out of agriculture, particularly smaller properties (Passmore and Brown 1992). To continue, producers may adopt increasingly unsustainable practices until the enterprise is completely unviable and unsaleable.

A decline in rural confidence, caused by perceptions about tree clearing restrictions, will also impact on land transactions by:

- increasing perceptions of risk in agricultural production, thereby increasing caution by potential purchasers;

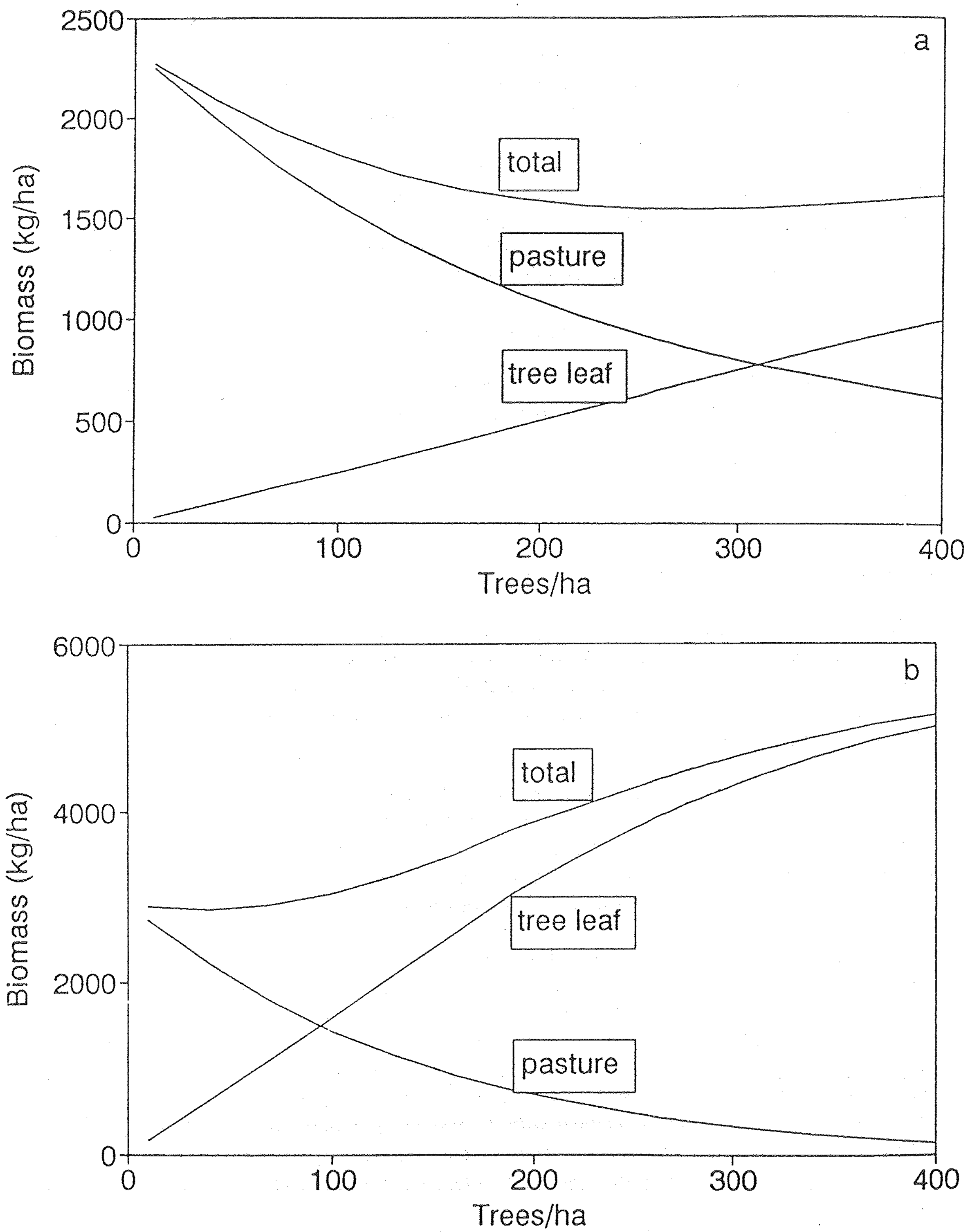


Figure 5 Biomass of tree leaf and pasture within (a) poplar box and (b) brigalow communities in Queensland. From Scanlan *et al.* (1992) with data from Burrows *et al.* (1990) and Scanlan (1991) respectively.

- reducing the value of some agricultural land, thereby reducing equity;
- restricting the availability of finance.

It could be suggested that producers and other community members may develop new opportunities such as tourism, ecotourism or cottage industries. These opportunities will depend heavily on the location of the community and its access to other resources or attractions. Generally however, the ability to diversify outside of agriculture is limited in each region. In some areas, tree clearing restrictions will also impact on those within the community that provide clearing contract services. For those that used the work to supplement other income or for those who made their primary wage from tree clearing, there are not many options for diversification. This again will have an impact on the economy of the community, in terms of a reduction in amounts spent on wages, machinery maintenance and fuel.

Overall, tree clearing restrictions have the potential of increasing the costs of Government through:

- increased demand for the exit provisions and productivity enhancement assistance of the Rural Adjustment Scheme and the Primary Industries Productivity Enhancement Scheme, and

- increased demand for social welfare support such as unemployment benefits, public health care, education support.

8.3 Economic impact of tree clearing on society

The economics of tree clearing can be assessed from both a private (or individual) and social perspective. Private analyses generally take the form of *financial and cost-effectiveness evaluations* whereby only cash flows in and out of an individual enterprise are considered. Such an approach does not account for impacts on other individuals, community groups or society as a whole (Department of Finance 1991).

An example of a financial evaluation is the analysis of the impact, in terms of reduced profit and land values, of tree clearing guidelines on individual landholders as referred to in the executive summary and sections 8.1 and 8.2. These evaluations are useful in that they provide valuable information on the financial impact of decisions at a property level but have limited use in determining the *total* economic impact of a decision or operation.

In a full *social benefit cost analysis*, all benefits and costs should be identified and assessed. These will include both positive and negative impacts on other individuals, groups and society. These sorts of impacts are known as *externalities* and for land clearing include the cost borne by society due to loss of biodiversity and visual amenity (Biological Diversity Advisory Committee 1992). An example of a positive externality is the contribution that increased production from tree clearing has made to the Australian economy in terms of employment, economic growth and exports. However, there are foregone costs associated with the loss of opportunity or value from other enterprises of future land uses. For example land clearing for the purposes of pasture production may exclude future native timber production, tourism or recreation opportunities.

Benefits and costs should be converted into dollar terms for comparison where possible. However, all *unpriced* benefits and costs should be qualitatively assessed and included in the analysis because they may influence the outcome of a social benefit cost analysis.

Once benefits and costs have been quantified, they need to be converted to a common value by using a *discount rate*. Social costs can then be subtracted from social benefits and unpriced impacts accounted for. If the benefits outweigh the costs the investment provides a *net present benefit* to society. Sensitivity tests can be used on key benefits and costs to take account of risk. A major problem is properly incorporating unpriced benefits and costs into the assessment and for this reason, assessments of net social benefit are difficult and expensive.

As James (1991) points out, environmental damage may occur if social costs are not accounted for in determining the economic feasibility of a development. If economic values are not placed on unpriced goods, inappropriate land use policies may result (Pearce and Turner 1990, James 1991, Chisholm and Dumsday 1987). Therefore, in order to properly evaluate the impact of tree clearing (and indeed the imposition of the draft tree clearing guidelines) an economic analysis where all benefits and costs are formally assessed, whether of a social or private nature, should be undertaken.

8.4 Potential production impact of tree clearing

A woodland management program carried out under the guidelines proposed by Burrows (1990, 1993) could theoretically lead to the development of up to 50% of the grazed woodlands remaining today (as assessed by WH Burrows). At the estimated rate of clearing used in the National Greenhouse Gas Inventory, this would take 70-100 years to achieve. Assuming a sustainable doubling of carrying capacity on treated land (Tothill 1983, Rae 1989) this suggests that there is the potential to increase stock numbers by *c.* 2M head (in beef cattle equivalents - based on average carrying capacity changing on remaining treated woodland from a beast to 15 ha, to a beast to 7.5 ha). The validity of these assumptions cannot be proven at this stage.

This potential may be constrained by other factors (including markets and the sustainability of such responses). Consideration of ongoing market developments in Asia and feedlotting point to the likelihood of a demand for increased cattle numbers over the next 20-30 years. As an example of the emerging demands it is suggested that by 2020, world cereal grain production will need to rise by 800Mt and fish by 16Mt per annum over to-day's levels (The Australian 29/6/95).

9.0 EFFECTS OF TREE CLEARING

The magnitude of any impacts from tree clearing will depend on a number of factors, including its local or regional extent, the prevailing and subsequent seasonal conditions, the methods used, and the subsequent use to which the land is put. The extent to which any impacts are exacerbated or ameliorated will depend to some extent on the way the land is managed. The regional consequences of extensive development are only now beginning to be seen in Australia (*eg* Hobbs 1993).

Generally, the biophysical effects of tree clearing are greatest when the land is cultivated, and least when selective tree poisoning, without pasture augmentation using exotic pasture, is practiced. Pasture augmentation may be undertaken at the same time as tree clearing, therefore the effects of pasture augmentation need also to be considered (Tothill *et al.* 1985, Bridge *et al.* 1983). The difficulties of managing augmented native pastures are outlined by Gardener and McIvor (1985), particularly when used in combination with feed supplements (Burrows 1991; Gardener *et al.* 1990). There are marked differences in responses among the variety of ecosystems that are developed in Queensland (Tothill and Mott 1985, Burrows and Scanlan 1984). At present, there are about 12 million ha of sown pasture within Queensland (Walker and Weston 1990, EJ Weston, personal communication), with perhaps 40-50 million hectares cleared. Therefore, extensive areas of cleared woodlands do not contain any sown pasture.

9.1 Runoff

The most important factor controlling runoff is the level of surface cover. The effect of trees on soils and pasture produce contrasting effects on runoff and erosion in woodland situations. The reduced pasture production observed in *Eucalyptus* woodlands of northern (Gardener *et al.* 1990), central (Scanlan and Burrows 1990) and southern Queensland (Walker *et al.* 1972) would suggest that runoff and erosion may be higher in grazed woodlands than in uncleared areas due to the lower pasture cover in the former areas. However, the presence of tree leaf litter can complicate this as there tends to be some buffering of the system - more trees leads to less pasture but increased leaf litter (Fig. 5, also see Burrows *et al.* 1990). The surface porosity and depth of the A horizon also tends to be higher under trees (Dowling *et al.* 1986), tending to increase the infiltration rates of the soils beneath trees (Johns 1981).

Runoff studies have been conducted in a number of locations in Queensland:

- In mulga lands, runoff under mulga leaf litter exceeded that from grassed areas by 2.8 mm/year (Miles 1993).

- Measurements of small catchments in Gayndah in a silverleaf ironbark/black speargrass community on a granite duplex soil showed no significant differences in runoff following clearing (Prebble and Stirk 1988).

- In central Queensland, small catchment studies in a brigalow community on fertile clay soils showed that clearing a brigalow scrub and establishing buffel grass pasture increased runoff by 21mm/year. Using historic rainfall data in the PERFECT simulation model, Littleboy *et al.* (1992) estimated that runoff doubles from 3 to 6% of the annual water balance (Lawrence *et al.* 1993).

- In the Upper Burdekin River Catchment, runoff was 50 to 70% lower under treatments that were cleared (with either native or sown pastures) compared with timbered areas (with *E. crebra, E. erythrophloia*); stocking rate had little effect on runoff (McIvor *et al.* 1995). Simulation studies by Scanlan and McIvor (1993) indicated that runoff was reduced by between 37 to 60% when trees were cleared from native pastures (at the same stocking rate). Stocking rate has an effect on the level of the reduction through the direct effect on surface cover.

- Pressland *et al.* (1991) showed the importance of cover in reducing both runoff and soil loss in grazed woodlands of north Queensland.

- A combination of neutron moisture meter studies and simulation modelling led Williams *et al.* (1993) to predict that there woule be an increase in runoff if trees were cleared on neutral red duplex and red earth soils in north Queensland. This is supported by Dilshad and Jonauskas (1992) working on similar soils in the Northern Territory. However, this is contrary to the data collected by McIvor *et al.* (1995) and the simulations of Scanlan and McIvor (1993).

- Williams *et al.* (1993) suggest a significant salinity hazard may exist in north Queensland. Clearing of woodlands on a wide range of soils was associated with increases in deep drainage in an environment having significant salt stores. They concluded tree clearing should only proceed after the evaluation of salinity risk. Induced salinity may not become apparent for at least 15-20 years after clearing (Coventry and Williams 1991).

- Wylie (1984) found a correlation between severe eucalypt dieback in southern Queensland and clearing rates in excess of 50%. Twenty-five percent of property owners reported salting of their water supplies in the same study.

9.2 Soil Movement

Clearing woody vegetation is often equated with increased levels of soil erosion in the long term. While this is certainly true where erosive rainfall is received when surface cover is low and where disturbance leads to the exposure of a dispersive B horizon in the soil, it is not a necessary consequence. A similar level of sheet erosion can be expected in ungrazed woodlands and in cleared, ungrazed areas. Accelerated sheet and rill erosion in both treed and grassed environments result from poor grazing and fire management. Because grass productivity is generally greater in cleared compared with treed areas, the intensity of grazing (stocking rate) that will accelerate erosion in treed areas is likely to be less than for cleared areas.

Heavy grazing may cause sheet erosion irrespective of the presence of trees (Gardener *et al.* 1990) as soil erosion in pasture land is greatly influenced by the extent of surface cover of vegetation (Ciesiolka 1987, McIvor *et al.* 1995). Densely timbered areas may have either more or less total cover of understorey plants and tree leaf litter than a cleared site depending on the species involved (Fig. 5). Trees compete directly with grass for water and nutrients and, in all but the monsoonal zones, this usually results in less herbaceous cover under trees than in cleared areas (Mott and Tothill 1984). Tree litter complicates this effect. This is exemplified by comparing Figs 5a and 5b. In *Eucalyptus populnea* woodlands (Fig 5a), there is a decline in total ground biomass (tree leaf litter plus pasture) as tree density increases due to the overriding negative effect of increasing tree density on grass cover. In *Acacia harpophylla* communities (Fig 5b) however, the highest total ground biomass is at the highest tree densities due to the higher relative production of tree litter. Ground cover is further modified by the interaction of grazing pressure, tree cover, use of fire and rainfall amount, intensity and distribution and the interactions between these create a complex set of erosion responses. Therefore generalisations about tree cover and surface soil erosion are not possible. Experimental data comparing areas before and after clearing are scant in Queensland. Studies that examine the rate of soil movement in grazed woodland systems are reported below:

- Studies on small plots in semi-arid tropical savannas of north Queensland showed that soil loss from areas with native pastures under trees was higher than for other pasture systems (cleared areas, with or without sown pasture). The soil loss from these pasture systems were from 13 to 56% of that measured from native pastures with live trees (McIvor *et al.* 1995).

- Simulation studies in the same area as above, showed a reduction in soil loss of between 53% and 85% when trees were removed from native pastures, with the actual figure being dependent on stocking rate (Scanlan and McIvor 1993).

- In mulga lands, cover levels above 34% reduced wind erosion losses to 0.2mm of soil per year compared with bare trampled ground which suffered from wind erosion losses exceeding 6mm per year. The extent of wind erosion is closely related to residual grass cover levels (Miles 1993).

- In soft mulga, average soil loss due to water erosion was 4.16 t/ha/yr with 20% cover, compared with 1.1 t/ha/yr when cover was 40%. Comparable figures for hard mulga were 6.57 t/ha/yr and 0.65 t/ha/yr (Miles 1993).

Clearing initially exposes the soil surface to higher surface temperatures which break down organic matter and reduce aggregate stability. Any associated mismanagement (such as overgrazing) combined with raindrop impact may lead to high surface strength of soils (Arndt 1965, Bridge *et al.* 1983), impeding seedling establishment. Any management practice that reduces soil cover is therefore detrimental.

9.3 Impacts on biodiversity

While the loss of biological diversity has been related to a wide range of factors including grazing, predation, changed fire regime and competition from feral animals (Morton 1990; Morton and Price 1994), the direct effects of tree clearing are widely recognised as a major cause of biodiversity decline in Australia (Ecological Sustainable Development Working Party on Biological Diversity 1991, Glanznig 1995). Native vegetation clearance has been very extensive in particular ecosystems and ecological communities - for example the clearing of extensive areas of brigalow (*Acacia harpophylla*) in Queensland (Gasteen 1987; Sattler and Webster 1984). However, it should be noted that tree clearing is not the only contributor to loss of biological diversity - overgrazing has been widely recognised as an important factor (Foran *et al.* 1990; Morton and Price 1994). Weeds are also recognised as a serious threat (Australian National Parks and Wildlife Service 1990, Humphries *et al.* 1991).

There has been little systematic analysis of species abundance in response to tree clearing in Queensland. However there are numerous examples of species that have decreased in abundance due to loss of essential habitat (diet, shelter, breeding sites) requirements supplied by trees. For example the disappearance of eight mammal species from the Brigalow Biogeographic region, is attributed largely to clearing and/or associated replacement of ground vegetation with exotic pasture species (Gordon 1984). These species were: the western quoll (*Dasyurus geoffroyi*), long-nosed bandicoot (*Peremeles nasuta*), the bilby (*Magrotis lagotis*), the brush tailed-bettong (*Bettongia penicillata*), the white-footed rabbit-rat (*Coniluris albipes*), the plains rat (*Pseudomys australis*), the Darling Downs hopping-mouse (*Notomys mordax*) and the canefield rat (*Rattus sordidus*).

There are many species of fauna which depend on trees and the habitat they provide and therefore undergo decreases in abundance and extent following tree clearing. For example: the glossy black cockatoo (*Calyptorhynchus lathami*, classified as Vulnerable) is dependant on brigalow/belah communities for habitat; the red-tailed black cockatoo (*Calyptorhynchus magnificus*), depends on supply of eucalypt seeds as its major food source; the ruffous bettong (*Aepyprmnus rufescens*) relies on eucalypt woodland for habitat; and various reptiles live almost solely on trees and under logs (*eg* tree dtella, tree skink which occur on gidgee and brigalow trees). Other examples of species directly impacted by tree clearing in the Roma area are given by McCabe and Eddie (1995).

Australia has a large number of obligate tree-hollow nesting birds. Hollows are characteristic of mature tree communities, and take centuries to form (Abensperg-Traun and Smith 1993).

Studies carried out in Queensland's Brigalow region (Russell *et al.* 1992) and similar areas in northern NSW (Barrett *et al.* 1994, Ellis and Wilson 1992) have confirmed the observations on individual species by showing that there is substantially more fauna (and sometimes flora) species in treed areas compared to adjacent cleared areas.

Systematic analysis of fauna from other parts of Australia where extensive tree clearing has taken place show the extent of biodiversity decline associated with tree clearing. Analysis of bird and mammal fauna of the semi-arid part of Western NSW have attributed the large proportion of species showing substantial decreases in abundance to a variety of reasons, including clearing of native vegetation (Dickman *et al.* 1993, Smith and Smith 1994). These trends also have occurred in other parts of Australia (*eg* Saunders *et al.* 1985, Barrett *et al.* 1994, Loyn 1987).

There are fewer obvious examples of plant species directly impacted by clearing (*eg* ooline (*Cadellia pentastylis*), other softwood species and Chinchilla white gum (*E. argophloia*) in the Brigalow belt). This could be at least partly because plants can survive for extended periods in small remnants (<5 ha) which are too small to support fauna species. However, the long term viability of such remnants is questionable (Hobbs and Saunders 1993). The decline in flora populations may be more insidious (McIntyre 1992) but, in the long term, just as severe as declines in fauna.

Other impacts on native species from tree clearing are from the effects of fragmentation and introduction of exotic pasture species that often accompany clearing (ANPWS 1990, Bishop *et al.* 1993). Fragmentation of native vegetation can lead to isolation of populations, for example the remnant populations of the two endangered species (the bridled-nail tailed wallaby and the northern hairy nosed wombat) that occur in the Brigalow belt. Isolated populations may be too small to be viable over a long period of time. Remnants are also subjected to altered fluxes of radiation, wind, water and nutrients, which can have a marked effect on the biota of the remnant especially near the edge (Saunders and Hobbs 1991). The effects of fragmentation can lead to displacement of native species (*eg* Hobbs and Saunders 1993) often for many years after the clearing has occurred (Saunders 1989). The negative impacts of tree clearing and fragmentation on native species is increased when exotic pasture species are introduced to cleared areas (*eg* McIntyre 1994). Sown pasture have been planted on about 6 million hectares in Queensland and have spread onto about an additional 6 million ha (E.J. Weston, personal communication).

The effects of fragmentation can be mitigated by considering habitat requirements in the development (see section 10.2, 10.3) of tree clearing management plans.

A consideration of the effects of tree clearing on biodiversity must look at various scales (West 1993), specifically the site and landscape scale (Cale and Hobbs 1994). Tree clearing and the associated creation of more open landscapes with increased grass cover and artificial water points has lead to increases in populations of some species such as plains turkey, galahs, cockatiels, woodswallows, budgerigars, zebra finches, diamond doves, pipits, songlarks and macropods (*eg* Saunders and Curry 1990). Clearing will favour some native species and in some situations plant species richness can be greater in cleared areas than in uncleared areas. Therefore at a landscape level the overall diversity may be greater where a mosaic of different plant community 'states' occur (Smith *et al.* 1995) than if the whole landscape is occupied by the same community.

However total numbers and abundances of (fauna) species generally decline in regions where clearing has taken place (Gordon 1984, Dickman *et al.* 1993, Smith and Smith 1994, Saunders *et al.* 1985, Barret *et al.* 1994, Loyn 1987). The 'different states' argument normally applies to complex spatial arrangements induced by variable grazing (Laycock 1994) or patchy fire (Griffin and Hodgkinson 1986) regimes such as the mosaics considered to be an essential component of the habitat requirements of some fauna species (e.g Bolton and Latz 1978, Friend *et al.* 1982, Southgate 1990). Clearing operations are not normally evenly distributed across landtypes or across the landscape (more productive land types are generally heavily cleared). Clearing is also often accompanied by the deliberate introduction of exotic pasture species or invasion by exotic weed species (Johnson and Mayeux 1992). While the invasion of exotic species may increase the number of species in an area (species richness) (Johnson and Mayeux 1992), some of these species become so well established that biodiversity (of native species) is reduced.

9.4 Nutrient cycling

The presence of trees is known to influence (generally increase) soil nutrient status, *eg* phosphorus in *Eucalyptus populnea* communities (Ebersohn and Lucas 1965); nitrogen and sulphur (Dowling *et al.* 1986). More recent studies have shown that the nutrient availability is improved beneath *Eucalyptus* canopies (Wilson *et al.* 1990), giving rise to a heterogeneous soil nutrient environment. A consequence of clearing is that this spatial variability is greatly reduced. This can be attributed to the reduced size of the plants that are using and redistributing the soil nutrients (grasses versus trees).

In the more fertile communities, there is also a reduction in the availability of soil nutrients as the time since clearing increases (Graham *et al.* 1981). This can be related to the increase in root biomass which tends to immobilise a large proportion of the available nutrient pool (especially nitrogen). No measurable decline in the total nutrient pool size has been recorded in these circumstances.

Trees are important in nutrient cycling and this leads to concern about the removal of trees and nutrient rundown. Many nutrients are associated with organic matter and any decline in soil organic matter will impact on nutrient availability. Dowling *et al.* (1986) showed that organic matter was much higher beneath tree canopies than in associated grassed interspaces in a brigalow-Dawson gum (*A. harpophylla-E cambageana*) woodland. In a brigalow forest nearby, soil organic matter did not decline in a five-year period after clearing and planting to buffel grass (*Cenchrus ciliaris*). An adjoining cropped catchment lost 19% of soil organic matter over the same period. Total nitrogen followed the same pattern. At least part of the 'lost' nitrogen in the first year after burning was due to uptake by pasture.

Data collected by Lawrence *et al.* (1993) in these brigalow catchments showed that within three years, soil organic carbon and total nitrogen under buffel grass were back to pre-clearing levels.

Phosphorus is a very important element but is not a mobile element within the soil profile. Losses can be expected where soil erosion is significant. If leaching and soil erosion losses are excluded, then the only loss from grazed communities will be in the form of livestock (meat and wool).

The amount removed will depend on stocking rate and soil fertility level. Assuming the stocking rate of 1 adult equivalent to 4 hectares, about 250g/ha of phosphorus will be removed in liveweight each year. There may be 30kg/ha of available phosphorus in the top 50cm of soil, indicating that stock could remove the available phosphorus in 120 years. However, the total phosphorus in the top 50cm of the soil would be about 1500-3000 kg/ha and the available pool is in dynamic equilibrium with this total pool. The removal of phosphorus by livestock is not a significant contributor to phosphorus dynamics in the medium to long term in grazed woodlands (Burrows 1993).

In the mulga lands, the concentration of topsoil nutrients and organic carbon (from highest to lowest) is found under mulga, grass, turkeybush, bare ground, eroded ground (Miles 1993).

9.5 Groundwater hydrology

The removal of deep rooted woody vegetation and its replacement by shallow rooted grass species leads to alteration of the hydrological relationships within catchments. Generally, the removal of trees increases the deep drainage component of the soil water equation. Specific studies of relevance to Queensland follow.

- A detailed examination of water use in a planted flooded gum (*Eucalyptus grandis*) agroforestry experiment showed that at higher tree densities, a greater proportion of soil water was extracted from deep within the soil profile, and that pasture growth was reduced at higher tree densities compared with unplanted areas (Eastham and Rose 1988, 1990; Eastham *et al.* 1988, 1990a, 1990b).

- Cleared mulga areas had up to 77mm less evapotranspiration compared with an area thinned to 640 trees/ha (Pressland 1976).

- Differences in water use can be demonstrated between native grasses, introduced shrubby legumes and *Eucalyptus spp.* in a north Queensland red earth (Gardener *et al.* 1990). Trees extracted water to a depth of at least 4m whereas grasses mainly used water from less than 1m of the soil.

- Catchment level effects of water use patterns could not be detected in a short-term study (Prebble and Stirk 1988) due to between catchment variability and between year variation in rainfall in southern Queensland ironbark/black spear grass woodland. Changes in chloride movement in the coarse granite soils of these catchments are unlikely to occur after timber treatment.

- Clearing brigalow (*Acacia harpophylla*) in central Queensland and planting a crop or pasture did not alter the annual catchment water balance (Lawrence and Sinclair 1989). The mean recharge rate measured by Lawrence *et al.* (1993) rose from 7mm to 28mm per year after establishing a buffel grass pasture but this was due to one very wet period (April/May 1983). Apart from this period, ground water recharge has been the same under buffel grass and brigalow.

- A one year study by Williams *et al.* (1993) in north Queensland showed increased deep drainage once trees were cleared - from 9 to 86mm for a red earth; from 118 to 238 for a sandy red earth; from 72 to 115 for a yellow podzolic. When these results were extrapolated for 100 years using the PERFECT (Littleboy *et al.* 1989) and SWIM (Ross 1990) models, increased deep drainage following clearing were from 15 to 74mm/year for a red earth and from 1 to 8mm/year for a neutral red duplex soil. This change in groundwater recharge in conjunction with soil salt levels of 0.4mS/cm and groundwater salinity levels of 1500 to 5000 mS/L present a potential salinity hazard after clearing.

- Bui *et al.* (1995) recommended tree retention on recharge areas which are adjacent to high risk areas (shallow groundwater and saline soils). Predictions of the risk of regional salinisation used soil profile descriptions, geology, estimated soil permeability/drainage characteristics, depth to groundwater, location of salt in the landscape and data from a water balance model.

- For most parts of Queensland (other than coastal and subcoastal areas and high rainfall areas of Cape York), evapotranspiration exceeds precipitation in most years. This suggests that groundwater recharge is small and irregular, and the mobilisation of salts is limited. This is in strong contrast with the situation in southern and south-western Australia where salinity problems are widespread. However, infrequent heavy rainfall events are important in overall recharge rates.

- An important consideration in hydrology is that woody plants reestablish or regrow in areas that are cleared, particularly when pulling/chaining or stem injection is the method of clearing. This is reported for eucalypt (Walker *et al.* 1972, Anderson *et al.* 1983, Burrows *et al.* 1988, McIvor 1989), brigalow (Anderson *et al.* 1984), gidgee (Reynolds and Carter 1993) and tea-tree (*Melaleuca*) communities (Anderson *et al.* 1983). The regrowth may support the same leaf area as uncleared woodlands, and therefore the hydrological regime may not differ greatly between intact woodlands and 'cleared areas' with woody regrowth. A factor of major importance will be the depth of rooting of mature trees versus regrowth. Unfortunately, no studies have compared these aspects.

9.6 Fire

The frequency with which an area can be burnt depends on herbaceous productivity and the rate of removal of standing dry matter. Removal of trees generally increases pasture production, often by a factor of 2 to 4 times. Removal of that dry matter by domestic livestock and native herbivores (vertebrate and invertebrate), and the removal of surface litter by termites and through breakdown by microorganisms will also generally increase. The relative balance between these competing factors will determine the fire frequency potential. Preliminary simulation studies in north Queensland woodlands indicates that in the absence of grazing, potential fire frequency was doubled by the removal of trees. Nevertheless, this potential has to be balanced against the extreme reluctance to use fire in drier inland areas of the State.

10. FACTORS LIMITING TREE CLEARING

10.1 Slope

Slope is an important factor in relation to the potential for soil erosion. While cover is the most important single factor influencing rates of erosion, slope is an important factor over which management has no control. Therefore there needs to be some limitations on the maximum slope for clearing.

Erosion is increased by the following factors:

- increased runoff which is dependent on soil surface conditions and permeability and to a lesser extent slope;

- speed of water flow which is a function of slope;

- erodibility of the soil which varies with soil type; and

- length of slope which in turn increases volume and speed of runoff water.

Killing trees with chemicals (using stem injection with herbicides or with ground application of root-absorbed chemicals) results in very little if any soil surface disturbance and the risk of surface-soil erosion is not significantly increased.

10.2 Wildlife corridors

Corridors of retained native vegetation, linking other remnant vegetation within an otherwise developed landscape, are an essential element of nature conservation planning at both a regional scale and at the property level (Chenoweth and Associates 1994). Definitions of corridors abound (Saunders and Hobbs 1991; Harris and Scheck 1991) but all contain key elements namely:

- a continuous strip of vegetation;
- usually links larger tracts of vegetation;
- used or capable of being used by wildlife for movement;
- capable of being a habitat in its own right.

Corridors may be classified accordingly to their continuity and connectivity as well as their origins (Loney and Hobbs 1991). Natural corridors, remnant corridors, restored corridors and riparian corridors are such examples with classification not necessarily mutually exclusive. Riparian corridors have been referred to as Australia's 'ecological arteries' (Recher 1993, Sattler 1993b). These corridors usually contain the most fertile and well watered part of the landscape and are highly significant from both a productive perspective as well as conservation.

Corridors, as remnants of once widespread and complex vegetation associations are subject to species losses and changes in ecosystem processes (Hobbs 1993). Being linear, they suffer a relatively larger edge effect, so that damage by fire, fertiliser drift, weed invasion, wind damage, insect defoliation, nutrient enrichment from run-on, microclimatic changes, hydrological changes, and many other impacts, greatly affect their sustainability (Hussey *et al.* 1989) (see Fig. 6). The nature and impact of the edge effects will be greatly influenced by the nature of the adjacent land use and the corresponding strength of the edge effect (Soule and Gilpin 1991).

Edge effects are the greatest threats to corridor stability. A sustainable corridor will have two zones, the outside areas that are effected by 'edge' processes, and an inner or core area. A corridor must be wide enough to ensure that an ecologically viable core area is sufficiently distant from the edges to be little effected by edge effects (Start 1991). A conservative approach that focuses on maximising corridor width is appropriate (Hussey *et al.* 1989), as this has been shown to be important for both birds and mammals (Lindenmayer and Nix 1993).

The impact of edge effects will also be determined to a certain extent by the natural vegetation of the corridor. In Western Australia, bird species richness in woodland corridors on road reserves was significantly influenced by the density of the ground cover below 1m high and the density of the vegetation above 8m. In mallee road reserves, only the width of the retained vegetation influenced bird species richness (Cale 1990). A study of birds in Toohey Forest found that a corridor width of 500m was required for small forest birds to avoid edge effects such as competition from more aggressive generalist bird species, which can displace specialist interior species 15-50m in from the edges (Catterall *et al.* 1991). Hussey *et al.* (1989) suggests that a rainforest corridor (that will be greatly affected by the drying effects of exposure) may need to be 100m wide, while in heath vegetation the minimum may be 30m.

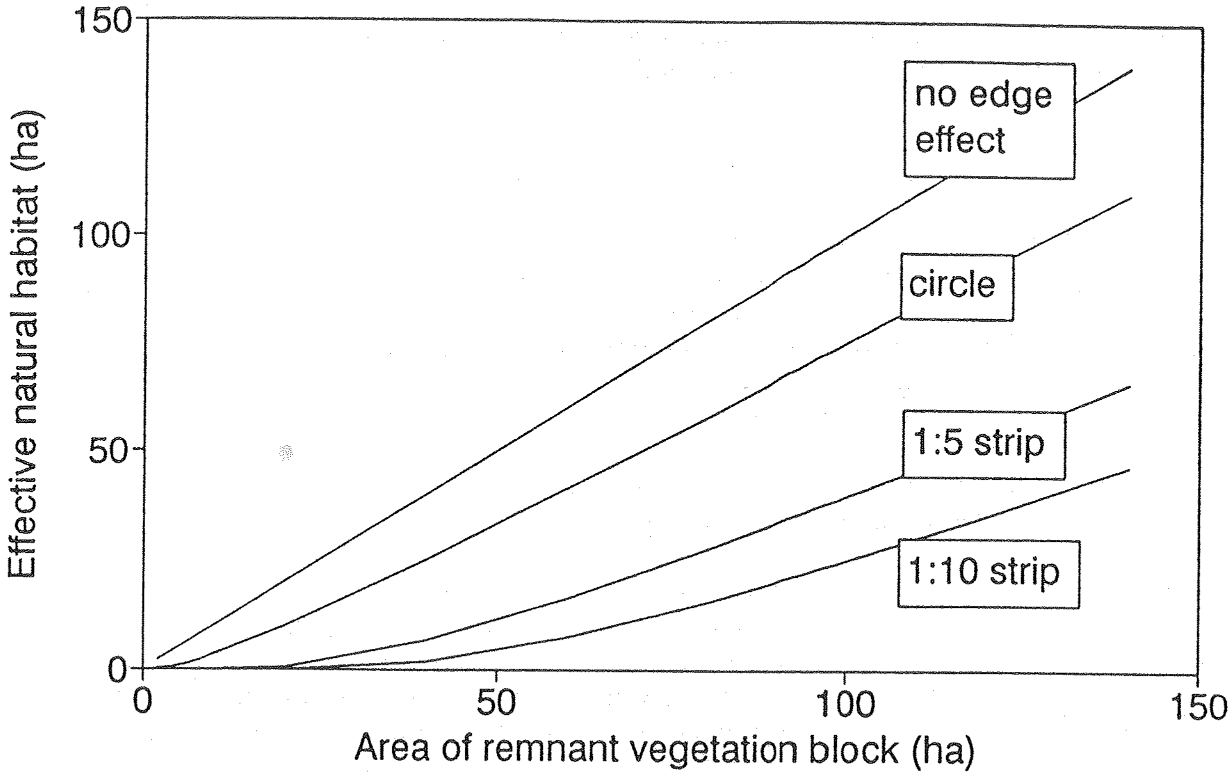


Figure 6 The effect of shape of retained vegetation on the area of natural habitat within that vegetation.

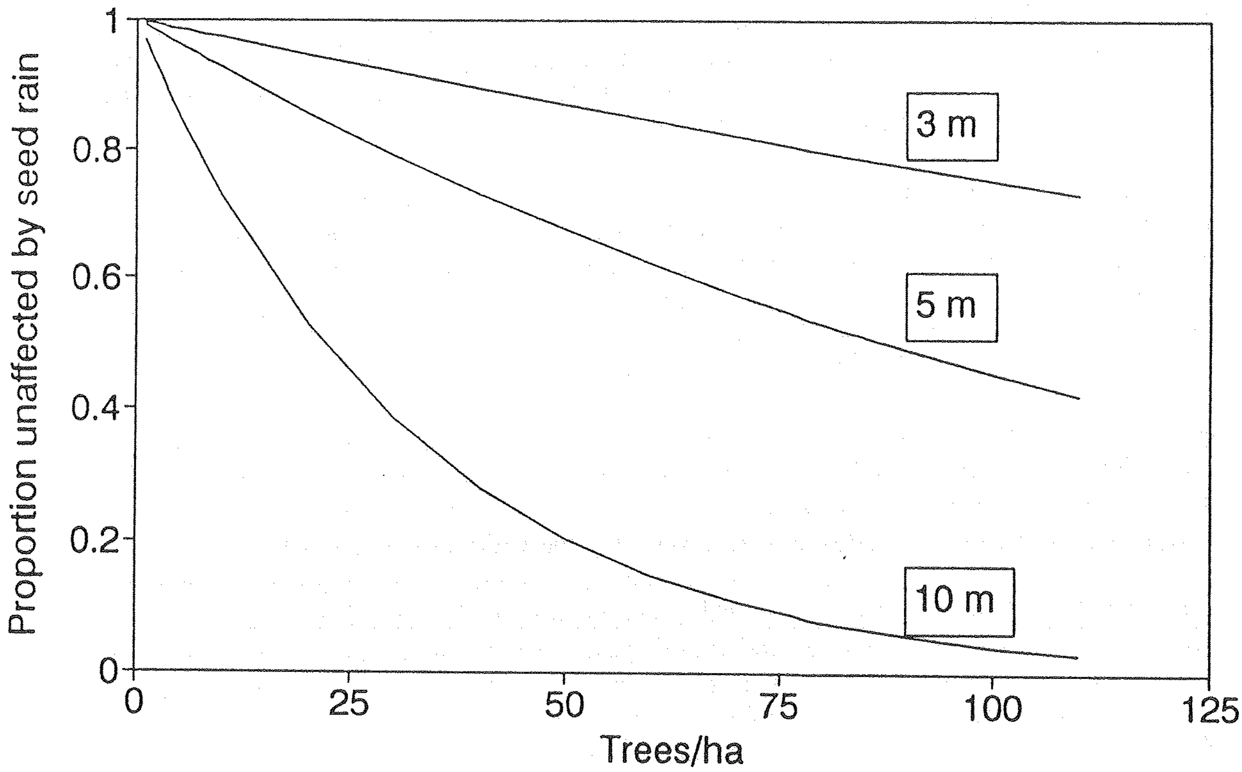


Figure 7 The proportion of an area that is not subject to 'seed rain' for a range of plant heights and densities.

Allowing for the generally denser vegetation in coastal areas and the likely edge effects caused by intensive uses such as sugar-cane cultivation, sown pastures and urban/rural urban sub-division, 100m would appear to be the minimum desirable width for sustainable corridors. Given the extent of the development and the low rate of retention of native vegetation, coastal corridors will also have a major function as habitat and should be made as wide as possible.

In inland areas, harsher and more frequent climatic extremes and extended seasonal food deficiencies mean that corridors need to be wider. This is also true because the generally sparser vegetation provides less protection for animal species from predators. Also, population densities are already relatively low and the chances of corridors becoming 'sinks' for some species are relatively high. The loss of smaller insectivorous foliage feeding birds facilitates insect outbreaks that may lead to repeated tree defoliation and eventual rural eucalypt dieback (Ford 1986). In these areas, 200m may be sustainable but variable such as corridor length and grazing pressures also need to be considered.

As pointed out by Chenoweth and Associates (1994) corridors must be managed with specific objectives in mind. Weeds have the potential to be the most serious threat to corridor integrity and must be addressed. Similarly pests, vermin and feral animals may also harbour in corridors and it is important to control problem species. Fire management must be considered especially when the dominant tree species is fire sensitive (*eg* mulga). Similarly management practices and operations (especially stock handling and mustering) have to be taken into consideration in developing appropriate strategies for overall management of corridors.

10.3 Retention areas

10.3.1 *Area of remnant vegetation*

The arid parts of the state are uncleared but have been disturbed by the grazing of sheep, cattle and feral animals. The native vegetation has not been removed but it has been markedly disturbed. Overgrazing, herbaceous vegetation change and subsequent soil erosion are major issues in these lands, as is the increase in undesirable native woody plants (Harrington *et al.* 1984). In contrast to the arid zone, areas suitable for agricultural crop production and intensive pasture development have undergone the greatest degree of clearing. Also, naturally treeless areas with fertile clay soils and sufficient rainfall (*eg* the Darling Downs and Central Highlands) have been cropped to such an extent that few areas of natural grasslands still exist.

Two separate considerations relate to appropriate retention of native vegetation. The first is the total area that should be retained, and the second is configuration (spatial arrangement) of retained vegetation. The total area to be retained may depend on regional hydrological, wildlife and soil movement considerations. It is difficult to determine an appropriate resource value for native vegetation. Extensive tree clearing has been associated with the relative ease of showing some private economic benefit from tree clearing (at least in the shorter term of c. 10-15 years). Once the total amount of vegetation to be retained has been determined, the aim must be to maintain the maximum degree of biodiversity possible. The habitat size required for, and appropriate population sizes of, flora and fauna are not well understood for even the most common species, making judgements about the required size of reserves very difficult.

10.3.2 *Fragmentation of remaining vegetation*

A consequence of agricultural development has been the vast reduction in native vegetation remaining intact, and the high degree of fragmentation that exists within the remaining vegetation (Wallace and Moore 1987). Fragmentation leads to two problems. Firstly, the viability of isolated small blocks of vegetation is generally poor (Hobbs 1991), even when these are protected from use by landholders and their domestic livestock. Conservation of flora may be achieved by reserving such areas, but fauna are at risk. The second aspect of the problem is lack of habitat diversity. In well developed agricultural areas, remaining vegetation tends to be a non-random sample of former habitats: swamps that could not be drained; steep hillsides; small patches of rainforest maintained for 'conservation'. These remnant patches support a narrower spectrum of flora and fauna than if all habitats were represented. Isolated blocks are not efficient in supporting a wide variety of native fauna and are prone to degradation from salinity, grazing, weed invasion and rising water tables (Hobbs 1987) should the required conditions for these be present. Interconnecting these remnant areas with wildlife corridors may enhance the value of reserved areas. A framework for the re-integration of remnant vegetation patches has been developed (Hobbs and Saunders 1991).

Reserves must be large enough to encompass the spatial processes and ecological gradients of the system being conserved (Usher 1987). Arguments can be proposed in favour of several small reserves as opposed to one large reserve. Those in favour of many small reserves concentrate on the number of species in these reserves and on which particular species can be protected (*eg* endangered species). A network of smaller reserves contain different (and more) species than a single large reserve of equivalent total area (Margules *et al.* 1988). Arguments favouring large reserves focus on the lower probability of extinction in large populations. A mixed collection of small reserves and large areas may be the best policy as some species are best protected by small reserves and others by large ones. Obtaining an answer to the question of the appropriate reserve size involves studying the biology and habitat needs of individual species, their minimum area requirements as well as factors restricting species distribution. Explicit procedures for selecting reserves for a nature conservation network have been proposed (Margules and Nicholls 1987, Margules *et al.* 1988).

10.3.3 *Configuration of remnant vegetation.*

Once a decision to retain a given area of native vegetation has been made, the next issue is where to leave that vegetation. The trend has been to clear the most productive elements within a landscape completely and to leave surrounding, less productive areas intact. While this may ensure that a large area of the property or paddock remains covered in woody vegetation, it reduces habitat diversity. Therefore any clearing should not exceed a maximum proportion of each habitat type. That proportion will vary between regions and the appropriate values to meet the multiple goals of agricultural production, water quality and fauna and flora conservation are not documented for most regions.

The most appropriate configuration of retained vegetation will depend on the planned land use. Where potential salinisation is a concern, intake areas should support native woody vegetation; where shelter from cold winds is required, south and south-western slopes should be left covered by trees; where trees actually encourage growth beneath their canopy, some scattering of trees may be beneficial. Scattered trees may also reduce temperature extremes and in tropical to subtropical environments this may be sufficient to prevent frosting of pastures (McIvor 1989).

Retained vegetation can be in the form of strips or clumps. Clumps are more effective in that a greater proportion of the total retained area is natural (minimal edge effect) compared with strips

(Fig. 6). The wider the strip, the larger the natural habitat area for the same reserved area. Strips also should interconnect with large undisturbed or natural habitat (clumps or reserves). Clumps must be large enough to support a viable population of wildlife and should be joined to other native vegetation areas to allow movement between major reserved areas.

A disadvantage of a high proportion of edge habitat is that this transition zone is prone to degradation and is not representative of the central zone of clumps or strips. The edge zones support some flora and fauna typical of the adjacent vegetation type. In cases where the retained vegetation borders sown pasture, plant invasion can be a significant form of natural habitat degradation.

Another option for retaining some woody vegetation and increasing livestock carrying capacity is to thin the existing stand, leaving a savanna landscape. This has aesthetic appeal, but in most situations a savanna is undesirable. Problems include 1) that the habitat for native fauna and flora is dramatically altered (unless the original vegetation was a savanna and the density had markedly increased); 2) that remaining trees are likely to have a shorter lifespan, and are more prone to insect and disease attack, and to fire damage; 3) that pasture production is often less from a savanna landscape than from an area in which the equivalent number of trees were retained in undisturbed habitat while the complement of the area was cleared (Burrows *et al.* 1988); and 4) the mature remaining trees are seed trees that ensure a seed source to re-establish new trees, thereby creating an inherent regrowth problem. As few as 40 trees/ha, each 10m high, can result in three quarters of an area being subject to seed rain (Fig. 7), whereas the same number of smaller trees potentially impact a mere 10% of the area.

A savanna landscape can be desirable where the canopied zone is more productive than the interspaces. Reasons for this include increased total soil nutrient levels (Dowling *et al.* 1986, Ebersohn and Lucas 1965), and indirect effects of shade (Wilson *et al.* 1986, Wilson *et al.* 1990). However, this situation occurs in very limited areas within Queensland.

10.4 Riparian zones

Riparian zones along rivers, creeks and gullies are the essential component of the landscape for the maintenance of wildlife distribution, abundance and diversity and for the maintenance of in-stream fauna (Sattler 1993b). Riparian zones act as 'refuges', providing resource rich habitats necessary for survival of (fauna) species during the course of their normal lifecycles (Gregory *et al.* 1991, Bunn 1993) or in times of drought (Morton 1990). They provide a rich and diverse habitat in their own right (*eg* Catterall 1993). Therefore riparian areas often provide habitat for a disproportionately high number of species relative to the proportion of the landscape they occupy. For example, riparian areas in the Mulga and south western Brigalow regions in Queensland (Neldner 1984 - Appendix 4) contain the highest number of plant species (27% of the total) compared to all other habitats, even though they occupy a relatively small area (<10% of the total area). Soft Mulga landtypes are the next richest 'broad' habitat type, containing 20% of the total number of species but occupying >20% of the area. Similar patterns occur for flora and fauna numbers in other parts of Queensland (Boyland 1984, McFarland 1992, Catterall *et al.* 1992, Crome *et al.* 1994) and, at least for bird species, in other parts of Australia (Recher *et al.* 1991, Loyn 1985, Gregory and Pressey 1982).

The importance of this zone for the protection of biodiversity and other natural resource values is being increasingly recognised (Bunn *et al.* 1993). Recently, this led to national programs being established by the Land and Water Resource Research Development Corporation (LWRRDC) to focus on the ecology and management of riparian zones in Australia.

Artherington *et al.* (1992) have summarised the importance of riparian vegetation in the development of linked habitat networks for regional or catchment planning by:

- forming corridors which link bushland remnants into sustainable regional networks;
- providing critical habitat refugia within which species are maintained in time of drought or fire;
- forming part of local habitat complexes which sustain terrestrial wildlife; and
- representing unique lowland communities subject to threatening processes

The significance of riparian lands for wildlife is such that they should be regarded as ecological *arteries* of the Australian continent, spreading as they do as a series of intricate interconnecting webs across the landscape.

Elsewhere in Australian significant funding is now being provided to re-establish cleared and degraded riparian zones *eg* Murray River of Green project.

Though riparian zones have been extensively cleared or degraded in many region of Queensland, significant area of intact habitat do remain (indicated by the status of riparian ecosystem types (Department of Environment and Heritage *in prep*).

Riparian zones serve diverse roles ranging from stream buffers to wildlife corridors. Accordingly, this zone should:

- include the ecotones between aquatic and terrestrial ecosystems along streams and adjoining wetlands and lakes;
- incorporate appropriate buffers to enable protection of these ecotones from disturbance from such factors as fire and weed invasion;
- enable the absorption of nutrients beyond the saturated zone and channelised areas draining directly into streams; and
- contain sufficient ecological integrity to act as effective wildlife corridors.

Research in Queensland (Catterall 1993) and overseas (Spackman and Hughes 1995) indicates that to be effective these corridors need to be of substantial width, particularly for avifauna. As an overseas example, for mid-order streams minimum widths of 75-175m were needed to include 90% of bird species (Spackman and Hughes 1995). In Southeast Queensland corridors greater than 200m in width have been recommended (Catterall 1993).

Riparian zones vary enormously in size depending upon their position within a river catchment *eg* gully head versus a lower reach of a river system. In lower parts of the catchment, the riparian zone increases in size, usually incorporating wetlands and significant areas of flood plains. While these areas are very productive and important wildlife habitat, they are very important to grazing livestock as well.

Other factors that have to be considered is the impact of riparian zone corridors on management practices (particularly mustering) and property operations (*eg* clearing of declared weeds such as rubber vine *(Cryptostegia grandiflora)*).

Accordingly, it is appropriate for buffer width standards to vary for gullies, creeks and rivers rather than a set figure being applied but the width should be such as to ensure the viability of the riparian zone buffer.

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APPENDIX 1: CLEARING IMPLICATIONS FOR PASTURE COMMUNITIES

DEFINITION OF CONDITION: (as cited in Tothill and Gillies 1992).

Sustainability: is the long-term maintenance of the livestock production resources and environment to enable viable livestock production.

Degradation: represents a departure from a sustained condition, resulting from an undesirable change in one or more elements that govern sustainability. Degradation embraces the whole production environment, not only land. Degradation is considered at two levels: *deteriorating* - a state reversible with appropriate management and normal rainfall; and *degraded* - probably irreversible within bounds of economic management.

Estimates of the extent of degraded associations are derived from the 1992 publication '*The Pasture Lands of Northern Australia'*, by the Tropical Grassland Society in a report commissioned for the Meat Research Corporation.

Descriptions of the zones are derived from published land system mapping by QDPI and CSIRO. Comments on management requirements and practices is based on research and experience (see References). Carrying capacity estimates are derived from Tothill and Gillies (1992), Partridge (1994, 1995), and Weston *et al* (1981).

DEFINITION OF CONSERVATION STATUS

The definitions of the conservation status of regional ecosystems have been provided by the Department of Environment and Heritage viz

Endangered: <5% pre-european extent remains in an intact condition[7] across regions. Given trends in land use, the regional ecosystem is at risk of disappearing from the landscape within the next 10-20 years.

Vulnerable: 5-10% pre-european extent remains in an intact condition in the region. Given recent trends in land use, the regional ecosystem is at risk over a longer period than 20 years through continued depletion.

Of concern: >10-30 pre-european extent remains in an intact condition in the region or is a spatially restricted ecosystem presently subject to threat of depletion. For the former, given recent trends in land use, the regional ecosystem could be substantially reduced in area in the medium to long term.

[7] It should be noted that an area may not be *intact* for reasons other than clearing. In particular, excessive or inappropriate grazing has caused a serious threat to some regional ecosystems. Cropping of grasslands and the spread of introduced species also contribute to this.

ZONE 1. *Aristida-Bothriochloa*

Description: Tea tree low woodland and eucalypt open woodlands of the southern Gulf and south-west Peninsula inter-river areas with *Aristida-Bothriochloa* tussock grasslands; seasonally waterlogged, infertile massive earths and sands.

Tenure: Leasehold, freehold (aboriginal tenures), reserves.

Condition: Some 10% degraded.
Less than 1% cleared.

Production: Carrying capacity 20-40 ha/hd under native pastures; limited potential for stylo development.

Biodiversity: Zone 1 contains elements of the Gulf Plains biogeographic region (provinces 4,5,6).

. of the 36 ecosystems in these provinces:

. 26 are of no concern
. none are endangered
. none are vulnerable
. 10 are 'of concern'

Refer to QDEH (1995b)(p8).

Impacts of clearing:

. Regrowth likely and woody weed potential.

Comments:

. Isolated region.
. Highly infertile soils; low erosion and salinity risks.
. Extensive production systems, low development potential.
. Tree clearing is not an issue in the vulnerable ecosystems (beaches, foredunes; fringing forests, levees)
. Tree clearing may be an issue in deciduous scrub communities.

ZONE 1: *Schizachrium - Sorghum*

Description: Tropical plains, low hills and flooded alluvial plains; open tea-tree or stringybark woodland with fire grasses, umbrella grasses, native sorghums and giant spear grass; leached sands, massive earths and seasonally waterlogged duplex soils .

Tenure: Leasehold, freehold (aboriginal tenures), reserves.

Condition: Some 10% of plains and low hills degraded; and 20% of alluvial plains degraded. < 1% cleared.

Production: Carrying capacity 20-40 ha/hd on flooded alluvial plains and >40 ha/hd on tropical plains and low hills.

Biodiversity: of the 127 regional ecosystems in this pasture community:

. none are endangered
. none are vulnerable
. 9 are 'of concern'

Refer to QDEH (1995b)(p10)

Impacts of clearing:

. Regrowth likely.

Comments:
. Low development potential; scope for intensive development in higher rainfall zones, especially with stylos.
. Highly infertile soils; low erosion and salinity risks.
. Tree clearing may be an issue on notophyll vine forests and monsoon scrubs and to a lesser extent on the stringybark open or ghost gum/ red box open woodlands, but these are mainly in reserves or limited by topography.
. Harvesting of stringybark is a commercial activity which contributes to pastoralists incomes on the Cape.

ZONE 2: *Gidgee*

Description: Open gidgee woodlands on shallow friable red earths and calcareous earths, often with gibber or stone cover and minor areas of alluvial soils, with georgina gidgee open woodlands and shrublands on gravelly loamy soils on limestone and dolomitic plains in the western border regions.

Tenure: Leasehold.

Condition:

Some 10% georgina gidgee degraded, and 45% other gidgee associations degraded.

Production: 12-35 ha/hd unimproved. Low development potential due to aridity and open nature of the gidgee woodlands and shrublands. Annual grasses, forbs and minor perennial grasses are main pasture species. Very difficult to establish sown species.

Biodiversity: Zone 2 contains elements of 4 biogeographic regions:

. North West Highlands
. Mitchell grass downs (western sector)
. Channel Country complex
. Mulga lands

of the 18 regional ecosystems:

. 3 gidgee ecosystems are considered vulnerable (mulga region)
. 4 gidgee ecosystems are considered 'of concern' (Mt Isa region and west of Winton)

These areas are important wildlife habitats particularly when surrounded by largely treeless areas (channel country and Mitchell grass) or where they are surrounded by more infertile areas (mulga).

Refer to QDEH (1995b)for details (pp 6,12, 15, 16).

Impacts of clearing:

Comments:

. Erosion gradients present and sodic subsoils present.
. Continue with current extensive pasture production systems.
. Clearing of gidgee and georgina gidgee is not an issue due to arid climate and open nature or shrublands and woodlands.

ZONE 2. *Mulga*

Description: Mulga woodlands and tall open shrublands and associated poplar box on red earth plains (eastern sector) and mulga/bastard shrublands mulga on dissected residuals and shallow loamy soils (western sector).

Tenure: Predominantly leasehold, limited freehold (eastern mulga), Reserves.

Condition: Some 30% of soft and hard mulga are severely sheet eroded and some 44% of properties having extensive woody weed invasion. Extensive scalding on riparian areas.

Production: 40 ha/hd on soft mulga to 50-60 ha/hd on residuals

Biodiversity: Zone 2 contains elements of 4 biogeographic regions:
. North West Highlands
. Mitchell grass downs (western sector)
. Channel Country complex
. Mulga lands

Of the 46 regional ecosystems in this Zone:

. Some 6 mulga ecosystems (mainly poplar box) are in the 'of concern' category due to tree clearing. These occur mainly east of the Warrego River.

•. Biodiversity in some areas limited by mulga densities.

A major issue for conservation of biodiversity from across the zone, relates to habitat modification/change in species composition and the loss of mosaic of treed versus grassed areas. The loss of wildlife 'refuge' areas (eg riparian areas) is also a major issue in this largely infertile pasture type. Tree clearing issues are difficult to consider in isolation from other land management practices, particularly grazing management during drought periods.

Comments:

. Highly infertile and massive soils with high erosion risk, and any loss of top soil leads to significant loss of surface nutrients.
. Development potential with tree clearing east of Warrego River for increased pasture production, and west of the Warrego River only for drought fodder production;
. Clearing undertaken for drought fodder and to open up dense mulga stands;
. Clearing should be done leaving large areas (mosaics) sufficient to minimise possible fire damage ;
. Need to balance pasture productivity with drought reserves and maintenance of biodiversity.
. Stocking rates set to consume less than 20% of available pasture and maintain ground cover above 20% canopy cover.

Zone 2. *Mitchell grass*

Description: Treeless open Mitchell grass plains on heavy cracking clay soils (Barkly Tableland), forbs on gibber plains or stony downs, and Mitchell grass ashy downs (Diamantina area).

Tenure: Leasehold.

Condition: Some 20% of stony and ashy downs degraded; 10% of open downs degraded.

Production: 10-15 ha/hd on Mitchell grass downs;
50-100 ha/hd on stony downs; and
35-80 ha/hd on ashy downs.

Biodiversity: Zone 2 contains elements of 4 biogeographic regions:
. North West Highlands
. Mitchell grass downs (western sector)
. Channel Country complex
. Mulga lands

Of the 27 regional ecosystems, there are major impacts on biodiversity due to invasion and displacement of native species by exotic weed species (especially prickly acacia *Acacia nilotica)* and grazing impacts on specific high conservation value areas.

Impacts of clearing:

. Not applicable - isolated trees occur on sandstone/mudstone outcrops and fringing channels - shade areas for stock.
. Prickly acacia, gidgee and other woody weeds invading downs, and present production problems. This increase in woody plants leads to loss of the mitchell grassland.

Comments:

. Continue current production practices.
. Retain tree cover for production purposes, and biodiversity.

ZONE 2. *Spinifex* - south.

Description: Spinifex open hummock grassland on dunefields of siliceous sands, interspersed by claypans and swales of gray clays with gibber cover.

Tenure: Leasehold, Reserves.

Condition: Some 20% degraded.

Production: 100-150 ha/hd carrying capacity.

Biodiversity: Zone 2 contains elements of 4 biogeographic regions:

- North West Highlands
- Mitchell grass downs (western sector)
- Channel Country
- Mulga lands

4 ecosystems are considered vulnerable in the dunefields.

There are 55 regional ecosystems in the spinifex pasture types. These areas contain relatively high species diversity, particularly within the reptile and threatened small-medium mammal groups. Management issues for biodiversity conservation relate mainly to impacts of fire (change from cooler patch burns to large intense fires) and feral animals (rabbits, cats and foxes).

Refer E&H publication (p14).

Impacts of clearing:

Comments:

- Continue extensive production practices.
- Clearing is not an issue in the dunefields, all cover required to stabilise dunes.
- Extensively represented in reserves.

ZONE 2. *Spinifex* - north.

Description: Spinifex open hummock grassland with snappy gum, bloodwood and acacia low open woodlands on shallow, stony red loams. Some steep areas associated with relatively fertile alluvium.

Tenure: Leasehold, Reserves.

Condition: Some 5% degraded.

Production: 40-150 ha/hd carrying capacity.

Biodiversity: Zone 2 contains elements of 4 biogeographic regions:

. North West Highlands
. Mitchell grass downs (western sector)
. Channel Country
. Mulga lands

41 ecosystems occur in the North West Highlands biogeographic region.

. 27 are of no concern
. none are endangered

. 5 are 'of concern'
. 9 are vulnerable

See comments for spinifex (south).
Refer to QDEH (1995b)(p6).

Comments:

. Broadscale tree clearing is not an issue due to arid climate, limited extent, topography, infertile stony and gravelly shallow soils and erosion gradients..
. Continue current extensive management practices.
. Cloncurry buffel some potential on fertile alluvium.

ZONE 2. *Channel Country.*

Description: Braided rivers and streams of the seasonally flooded Channel Country,; seasonal herbfields and grasslands with river red gum and coolabah fringing channels and lignum in swamps; very deep, grey alluvial clays.

Tenure: Leasehold.

Condition: Some 20% of interchannel areas degraded.

Production: Seasonal grazing only with summer grasses after summer floods, and forbs after winter floods; 25-40 ha/hd carrying capacity.

Biodiversity: There are 23 regional ecosystems in the Channel Country biogeographic region, and one (1) is 'of concern' due to its limited distribution and grazing impacts.

Major management considerations for biodiversity are the control of feral animals and the impacts of grazing on particular parts of the landscape (eg waterholes).

Impacts of clearing:

Comments:

. Tree clearing is not an issue in the Channel Country.
. Trees required to stabilise channels and for shade.
. Continue current extensive management practices.
. Some trees have commercial value for honey production (flooded yapunyah).

ZONE 3. *Gidgee* - Desert Uplands.

Description: Gidgee shrubby woodlands with sandalwood, currant bush and emergent eucalypts; moderately grey clay soils with shallow gilgais and loamy soils. Some stony alluvial clays associated with prior channels of Torrens Creek.

Tenure: Leasehold

Condition: Some 20% degraded.
10% cleared - north
80% cleared - south

Production: . 20-30 ha/hd uncleared to 100 ha/hd (unusable) and
. 7-10 ha/hd cleared and sown to buffel grass - north, 6-10 ha/hd - south.

Biodiversity: Of the 61 ecosystems in the Desert Uplands biogeographic region:

9 have a significant component of gidgee, brigalow or blackwood.

. none are of no concern
. none are endangered
. 6 are vulnerable
. 3 are 'of concern'

Refer to QDEH (1995b)(p25).

Impacts of clearing:

gidgee regrowth likely;

Comments:
. Represent the most productive areas on 'desert' blocks and need to be managed as discrete units;
. All the acacia communities are subject to applications to clear.
. The relatively extensive gidgee scrubs on alluvial clays in the north of the region have State-wide significance for the conservation of this community
. Enables breeding and fattening.
. Low erosion gradients.
. Salt claypans with hard spinifex associated with gidgee outliers near Barcaldine

ZONE 3. *Desert Uplands* (A)

Description: Eucalypt woodland of yellowjacket with or without spinifex; grading into Normanton box/ teatree-desert oak/grevillea woodlands, or ironwood and wilga on lake frontages; some coolabah on alluvial flats.

Tenure: Leasehold.

Condition: Some 20% degraded.

Production: 20-40 ha/hd in natural state. No broadscale clearing being done.

Biodiversity: of the 61 ecosystems in the Desert Uplands biogeographic region: 22 are eucalypt communities:

. 14 are of no concern
. 1 is endangered (lake dunes and fringes)
. 3 are vulnerable
. 4 are of concern

Refer to QDEH (1995b)(p25).

Comment:

. Tree clearing is not generally recommended in these associations.
. These are not the subject of clearing applications.
. Offsite salinity *eg* in gidgee on western margins, and tableland toeslopes is possible following clearing of groundwater intake areas.
. Eucalypt regrowth will require regular treatment. At present, the costs of such treatments may exceed the value of the land.

ZONE 3. *Desert Uplands* (B)

Description: Eucalypt woodlands of poplar box and/or silverleaf ironbark and/or wilga with or without spinifex, wiregrasses and desert bluegrass.

Tenure: Leasehold.

Condition: Some 20% degraded.
< 5% cleared north
30% cleared south

Production: 20-40 ha/hd uncleared;
9-12 ha/hd cleared and sown to buffel grass - north
7-10 ha/hd cleared and sown to buffel grass - south

Biodiversity: Of the 61 ecosystems in the Desert Uplands biogeographic region, 9 are eucalypt communities with mid-height grassy understoreys:

. 3 are of no concern
. none are endangered
. 1 is vulnerable
. 5 are of concern

Refer to QDEH (1995b)(p25).

Impacts of clearing:

. Tree clearing has potential to improve pasture production.
. Eucalypt and acacia regrowth likely.

Comments:

. The red earth soils are particularly vulnerable to erosion due to massive soil structure and long slopes.
. Scalded soil surfaces may present difficulties to seedling establishment;
. Buffel grass may establish in small but 'fertile' locations within this landscape.
. These associations are subject to clearing applications.

ZONE 4. *Aristida-Bothriochloa* (southern Gulf Plains).

Description: Plains of erosion, red and yellow earths with silver leaf box, snappy gum, bloodwood and stringybark; wire grasses and gulf blue grass; minor tea tree low woodlands.

Tenure: Leasehold, Reserves.

Condition: Some 10% degraded.

Production: 20-40 ha/hd uncleared.

Biodiversity: Of the 79 ecosystems in the Gulf Plains biogeographic region, this Aristida-Bothriochloa association is in the 'of no concern' category.

Refer QDEH (1995b) publication (p8).

Impacts of clearing:

. Regrowth likely.

Comments:

. Isolated and very limited community. Clearing not an issue.
. Highly infertile soils, very low erosion risk.

ZONE 4. *Gidgee* (southern Gulf Plains)

Description: Gidgee low open woodlands on colluvial slopes with arid short grasses; red loamy soils and minor clays.

Tenure: Leasehold.

Condition: Some 10% degraded.
< 5% cleared.

Production: 20-30 ha/hd uncleared.
7-10 ha/hd cleared and sown to buffel grass.

Biodiversity: within the Gulf Plains biogeographic region, of the associations dominated by gidgee:

. 2 are not of concern
. 1 is 'of concern'

Refer QDEH (1995b) publication (p7,8).

Impacts of clearing:

Little is known of its response to clearing and the land management requirements.

Comments:

. Widespread clearing not appropriate due to aridity. Soils are variable in fertility. In general, only small areas are involved.

ZONE 4. *Gidgee* (associated with Mitchell grass downs)

Description: Gidgee woodlands often with shrub layer on deep, brown and grey cracking clay soils and minor loamy duplex soils, occasional stone cover.

Tenure: Freehold, freeholding leases, leasehold.

Condition: Some 30-40% degraded.
70% cleared.

Production: 20-30 ha/hd uncleared and
8-16 ha/hd cleared and sown to buffel grass.

Biodiversity: There are 10 regional ecosystems in this pasture type of which 4 are considered vulnerable and 2 are considered 'of concern' due to the extent of tree clearing. Most of the clearing in this zone has occurred east of Longreach and these communities are 'of concern' or 'vulnerable'. These ecosystems provide important wildlife habitat in the surrounding, largely treeless region.

Refer QDEH (1995b) publication (p13).

Impacts of clearing:

Comments:

. Gidgee is invading surrounding open Mitchell grass downs.
. As extensive areas of gidgee have been cleared and sown to buffel grass (some 70%), all gidgee associations are considered vulnerable in the Zone 4 *eg* Winton area.
. Management of gidgee invading open Mitchell grass downs is required.
. Gidgee clumps in downs are increasing in density.
. Sodic subsoils.
. Salinity outbreaks at toe-slopes of adjoining tablelands

ZONE 4. *Spinifex* - (southern Gulf Plains)

Description: Soft spinifex, wiregrasses and gulf bluegrass on plains and low rises and plateaux; gravelly and sandy soils with sparse silverleaf box, snappy gum low open woodland.

Tenure: Leasehold.

Condition: Some 5% degraded.

Production: 40-150 ha/hd carrying capacity.

Biodiversity: Refer to QDEH (1995b) (p9)

Impacts of clearing:

Comments:

. Continue current extensive management practices and use in conjunction with clay plains.

. Tree clearing not an issue due to aridity, highly infertile gravelly soils and erosion risk.

ZONE 4. *Bluegrass Browntop* (southern Gulf Plains)

Description: Bluegrass browntop grasslands on grey cracking clay soils of alluvial plains; coolabah fringing streams and channels.

Tenure: Leasehold.

Condition: Some 10% degraded.

Production: 12-16 ha/hd carrying capacity.

Biodiversity: occurs in Gulf Plains biogeographic region.

. The grassland is in the 'of no concern' category.

Refer QDEH (1995b) publication (p9).

Impacts of clearing: Not applicable.

Comments:

. Continue current production practices.
. Some treatment of dense patches of coolabah seedlings along watercourses may be appropriate, but otherwise retain all tree cover for shade and biodiversity purposes.

ZONE 4. *Mitchell grass downs*

Description: Mitchell grass tussock grassland, with isolated myall, bauhinia, boonaree on sandstone or mudstone outcrops; moderately deep, grey and brown self-mulching cracking clay soils; coolabah and river red gum fringing channels and streams.

Tenure: Freehold, leasehold.

Condition: 15-20% degraded.

Production: 10-15 ha /hd.

Biodiversity: There are 17 regional ecosystems in Zone 4. Major impacts on biodiversity are due to invasion and displacement of native species by exotic environmental weed species and grazing impacts on specific high conservation value areas.

QDEH (1995b) (p12) lists the gidgee treed areas on the downs as vulnerable.

Impacts of clearing:

Not applicable.

Comments:

. Continue current management practices.
. Retain wooded sandstone outcrops (bauhinia, boonaree, vinetree, whitewood).
. Management of expanding gidgee areas requires management.
. The exotic species *Acacia nilotica, Prosopis, Parkinsonia* are becoming widespread woody weeds that are declared weeds and must be controlled.

ZONE 5. *Black spear grass* (Einasleigh Uplands)

Description: Silverleaf and narrowleaf eucalypt open woodland, minor grey box open woodlands on infertile duplex and red earth soils with black speargrass, kangaroo grass and desert blue grass and Indian couch.

Tenure: . Predominantly leasehold and limited freehold.

Condition: Some 15% of black spear grass degraded.
5% cleared, mainly Charters Towers region.

Production: (cleared)
. 2-4 ha/hd on frontage speargrass country
. 6-10 ha/hd narrowleaf ironbark on basalt
. 10-12 ha/hd narrowleaf ironbark and speargrass
. 3-5 ha/hd narrowleaf ironbark and stylos

Biodiversity: Contains the Einasleigh Uplands biogeographic region and a province of the Gulf Plains. Of the 13 Gulf Plains communities:

. 13 are of no concern

Refer QDEH (1995b) publication (p23).

Of the 24 eucalypt ecosystems in the Einasleigh Uplands biogeographic region with a black speargrass understorey, all are of 'no concern'.

Impacts of clearing:

- Regrowth likely.

Comments:

. Tree clearing applications likely.
. Tree density in the northern speargrass lands is much less than tree density in the southern speargrass region and consequently pasture is reasonably productive in uncleared state.
. Erosion gradients commonly present. Sodic subsoils in eucalypt woodlands.
. Salinity risk to be assessed before clearing *eg* granodiorite areas.
.The pattern of rainfall also leads to a lower impact of trees on pasture production compared with southern speargrass, especially on less fertile soils.
. Trials on fertile basalt soils show marked increases in pasture production following clearing.
. Extensive clearing in Charters Towers region.
. Increased pasture production follows clearing but regrowth from eucalypts and acacias is a major management problem.
. Sowing stylos in undisturbed woodland is generally considered more profitable but is not widely practised.

ZONE 5. *Aristida Bothriochloa* (Einasleigh Uplands)

Description: Poplar box and narrowleaf ironbark open woodlands with wiregrasses and desert blue grass on red earths and duplex soils.

Tenure: Predominantly leasehold, limited freehold.

Condition: Some 20-30% degraded.
< 5% cleared.

Production:
. 18-30 ha/hd in western sectors and
. 6-10 ha/hd in more mesic eastern sectors.

Biodiversity: Of the 8 ecosystems in the Einasleigh Uplands biogeographic region dominated by this pasture association:

. 4 are of no concern
. 4 are of concern

Refer QDEH (1995b) publication (p23).

Impact of clearing:

. Regrowth likely.

Comments:

. Clearing applications likely.
. Sodic subsoils and erosion gradients.
. Assess salinity risk before clearing.
. Tree clearing may be an issue on softwood scrubs, and gidgee woodlands.

ZONE 6. *Queensland bluegrass* (central Qld)

Description: Bluegrass tussock grassland with scattered bloodwoods and mountain coolabah on basalt rises and outcrops; deep cracking clay soils.

Tenure: Freehold.

Condition: 60% degraded (Parthenium).

Production: 3-6 ha/hd carrying capacity, but extensively cropped.

Biodiversity: The bluegrass association is considered endangered in the Brigalow biogeographic region, mainly from cropping and Parthenium invasion rather than clearing. Six regional ecosystems occur in this pasture type; two are classified as 'endangered'; two as 'vulnerable'; and two as 'of concern'. Several rare and threatened plant species occur in remaining remnants.

Refer QDEH (1995b) publication (p27).

Impact of clearing:

. Not applicable.

Comments:

. Minor salting with irrigated cropping.
. Continue current cropping practices and retain trees (mountain coolabah/bloodwoods) where possible within cropping systems.

ZONE 6. *Aristida Bothriochloa* (Brigalow Belt and New England Tablelan d)

Description: Poplar box woodlands (north) and mixed eucalypt-acacia open forest (south) on infertile sandy duplex soils; with open eucalypt woodlands on 'traprock' sandy duplex soils derived from granite and sandstones (border country).

Tenure: Freehold, with leasehold and Reserves.

Condition: Some 20-30% degraded.
20% cleared north,
20% cleared central,
30-40% cleared south.

Production: . 6-10 ha/hd (north), and
. 6-14 ha/hd (south).

Biodiversity:

There are 86 regional ecosystems in this pasture type and 6 are classified as 'vulnerable', and 18 as 'of concern' due to the extent of tree clearing. Four of the 'vulnerable' ecosystem types are alluvial flats in the northern New England tableland. Most of the 'of concern' ecosystems include better quality eucalypt woodlands in the Brigalow belt that have been subject to extensive clearing.

Refer to QDEH (1995b)(p27, 36).

Impact of clearing:

. Regrowth is common and there is little effective clearing.

Comments:

. This is a major regional corridor along the Great Divide and possible fragmentation of habitat is an issue.
. Tree clearing has increased pasture production.
. Dieback in traprock country and trees should be retained, especially in catchment that have been extensively cleared.
. The timbered eucalypt areas are important as managed in conjunction with the adjacent cleared brigalow areas.

ZONE 6. *Brigalow, Blackwood, Gidgee.*

Description: Brigalow/Dawson gum; brigalow/yellowwood, brigalow/softwood, brigalow gidgee in north on cracking clays and duplex soils; to brigalow/belah/wilga on clay sediments; to brigalow/belah on deep, gilgaied clays; blackwood/gidgee scrubs and softwood scrubs.

Tenure: Freehold and leasehold, reserves.

Condition: 30% degraded (parthenium)
80% cleared north
90% cleared central
99% cleared south

Production: 4-8 ha/hd cleared and sown to improved pastures. Extensively cropped.

Biodiversity: There are 31 regional ecosystems in this pasture type. Of these, 8 are types of 'softwood shrub' (or dry rainforest) which have been reduced in extent and are important habitat for many flora and fauna species. Or the remaining types, 14 are classified as 'endangered'; 6 as 'vulnerable';; and one as 'of concern' due to the extent of clearing. The loss of extensive areas of these habitat types due to tree clearing and (in most cases the associated conversion of areas to improved pasture) is associated with displacement/loss of native species which rely on these habitat types.

Refer to QDEH (1995b)(p27) for conservation details of brigalow associations.

Impacts of clearing:

. Extensively cleared to produce stable and productive pasture and cropping system.
. High regrowth potential but can be economically controlled

Comments:

. Sodic and/or saline subsoils.
. Retain brigalow, blackwood and gidgee remnants for biodiversity considerations.
. Need to manage/control regrowth unless original clearing was inappropriate.

ZONE 6. *Lancewood, bendee, rosewood* (brigalow belt).

Description: Lancewood, bendee and rosewood woodlands on steep slopes, hills and tablelands.; skeletal soils on slopes with red earths on tablelands.

Tenure: Freehold and leasehold.

Condition: Generally poor.

Production: 40-50 ha/hd.

Biodiversity:

There are 11 regional ecosystems in this pasture type. These are generally not cleared and therefore none are listed as 'of concern'. There are a high number of rare species associated with these communities.

Refer QDEH (1995b) publication (p27).

Impact of clearing:

. Accelerated erosion likely on steep slopes.

Comments:

. High erosion potential on scarps and colluvial slopes.
. Limited 'harvesting' of timber for fence rails and posts.
. Tree clearing not an issue due to steep slopes, rocky soils and infertile red earths.
. Clearing of bendee on tablelands not appropriate.
. Salt outbreaks on toe-slopes of tableland areas possible.

ZONE 6. *Mitchell grass* (brigalow belt)

Description: Mitchell grass downs with scattered myall, bloodwood and river red gum and coolabah fringing streams; deep grey cracking clays.

Tenure: Predominantly freehold; some leasehold on NSW border region.

Condition: Some 80% in good to fair condition.

Production: 10-15 ha/hd, but extensively cropped.

Biodiversity:

There are 9 regional ecosystems in this pasture type, of which 3 are listed as 'of concern' and one as 'vulnerable'. One of the 'of concern' types is a grasslands and tree clearing is not an issue. (There are also a high number of rare species associated with these communities). The loss of extensive areas of these habitat types to cultivation is associated with displacement/loss of native species which rely on these habitat types and is an issue in the east of the zone. Two of the 'of concern' and one 'vulnerable' ecosystems are coolabah/blackbox woodlands on the Culgoa floodplain and therefore tree clearing of these communities is an issue.

Refer QDEH (1995b) publication (p27).

. These grasslands are considered endangered or vulnerable due to cropping inroads.

Impacts of clearing: Not applicable.

Comments:

. Primarily freehold tenure.
. Continue current cropping practices and retain (wooded) tree cover where possible.

ZONE 7. *Black spear grass*

Description: Eucalypt woodlands and forests with speargrass, forest blue grasses on duplex, alluvial and red earth soils.

Tenure: Freehold, reserves, limited leasehold.

Condition: Some 20-30% degraded.
60% cleared north of Miriam Vale
30% cleared south of Miriam Vale.

Production:

. 3-4 ha/hd on cleared blue gum flats

. 8-10 ha/hd uncleared silverleaf ironbark
. 3-5 ha/hd thinned silverleaf ironbark
. 3-5 ha/hd thinned + legume

. 10-12 ha/hd uncleared narrowleaf ironbark
. 3-5 ha/hd thinned
. 3-5 ha/hd thinned + legume

. 10-20 ha/hd uncleared spotted gum rises
. 3-5 ha/hd thinned spotted gum rises
. 3-5 ha/hd thinned + legume

Biodiversity:

Refer QDEH (1995b) publication pp27, 33.

There are 78 regional ecosystems in this pasture type which includes parts of the South East Queensland and Brigalow Belt biogeographic regions. Five ecosystems are endangered, 11 are vulnerable and 22 are 'of concern'. These are generally associated with the flatter and/or more fertile parts of the area that have been extensively cleared or thinned. The hills and ranges remain heavily timbered.

Impacts of clearing:

. Eucalypt regrowth
. Acacia regrowth likely.

Comments:

. Considerable pasture production increases with thinning and legumes.
. Erosion potential.
. Assess salinity risk before clearing.
. Adopt recommended tree management practices.
. The extent of clearing that is appropriate, depends on current clearing status.
. Retention of trees for timber purposes is important.
. Selective tree thinning above 20% slope may be possible.

ZONE 7. *Brigalow*

Description: Brigalow, belah, wilga woodlands and forests on unconsolidated clay and argillaceous sediments; minor softwood associated.

Tenure: Freehold, reserves.

Condition: Some 20% degraded.
95% cleared.

Production: 2-6 ha/hd cleared and improved pastures, often cropped.

Biodiversity: Refer QDEH (1995b) publication p33.

There are 9 regional ecosystems recognised in this pasture type in western Southeast Queensland and eastern Brigalow Belt biogeographic regions. Four are endangered and five are vulnerable due to extent of clearing.

Impact of clearing:

. Extensively cleared to produce stable and productive pasture and cropping system.
. High regrowth potential but can be economically controlled

Comments:

. Sodic subsoils.
. Steep slopes predispose soils to erosion.
. Some salinity associated with irrigation.
. Extensively developed to cropping and pastures.
. Continue cropping and pastoral practices.
. Retain areas of virgin brigalow and softwood scrub.

APPENDIX 2: DESCRIPTION OF LAND TYPES (NATIVE PASTURE COMMUNITIES) ex Weston *et al.* (1981).

The most suitable basis for developing tree clearing guidelines is a classification that combines areas with similar soils and vegetation types as these are the elements that determine the reaction of a vegetation community to disturbance. Weston *et al.* (1981) produced a map of native pasture communities, and this was used as a basis for the clearing zones in the Draft State Guidelines.

The Department of Environment and Heritage have developed a bioregional classification system which divides Queensland into 13 bioregions, each with characteristic set of geologies, landforms, soils and vegetation communities. These regions are further divided into a variable number of provinces, and the provinces are divided into regional ecosystems. The 924 regional ecosystems are recognisable as land types in the field and are based on vegetation types as described in vegetation mapping studies done since the 1950s. Thus, there is some possibility that the composition and density of these ecosystems differ from the pre-european settlement conditions.

These regional ecosystems should be used as a basis for determining which vegetation types should be identified in local guidelines. The Department of Environment and Heritage has identified which of the 924 regional ecosystems are endangered, vulnerable and of concern, based upon publications and experience of field officers. The areas of these regional ecosystems are not available as they have not been mapped.

The definitions of the conservation status of regional ecosystems are defined according to the amount of the communities remaining in an intact condition. An *intact* ecosystem is one that has not been altered in structure or composition as a result of land management. Contributing to the alteration are tree clearing, excessive grazing, soil erosion and weed invasion.

Description of communities

A brief statement is given here on each of the 14 communities: the characteristic ground cover grasses and the dominant tree species are indicated.

1. Pastures sparse or absent

Closed forests and two coastal communities, namely rainforest, littoral and heath, are grouped together because they have limited usefulness for animal production in the natural state. The total area they cover is 4.4M ha. Rainforest has few grasses until cleared when *Melinis minutiflora, Pennisetum clandestinum, Paspalum dilatatum* and *Axonopus affinis* may become naturalised.

Although the littoral areas contain a rich ground flora, pastures of *Spinifex hirsutus* have a low productive value. The exception is on some tidal flats where valuable seasonal grazing is obtained from *Sporobolus virginicus*. The sedge *Schoenus sparteus* occurs as a characteristic species on the heath of Cape York Peninsula.

Prominent soils in the rainforest areas are friable earths and fertile loams; in littoral zones they are plastic clays and texture contrast soils with gleyed clayey subsoils; and in heath areas, infertile earths.

2. Blady grass

A composite of northern and southern sandy coastal lowlands, these open forest and woodland communities cover an area of only 2.7 m ha and generally receive more than 1100 mm of rainfall a year. The major trees in the north are *Eucalyptus platyphylla, E.papuana* and bloodwoods; and in the south, *E.signata,* bloodwoods and *Melaleuca* species. The characteristic grasses are *Themeda triandra* and *Imperata cylindrica* with *Heteropogon triticeus* associated in the north and *A.affinis* in the south. Intensive use is not possible in the absence of expensive land development.

Soils are infertile, mostly with a shallow A horizon and an impervious B horizon in the duplex profiles.

3. Black spear grass

Black spear grass (*Heteropogon contortus*) is the most extensive native pasture community in the humid and sub-humid zones. It occupies 25 m ha and for the most part receives between 700 mm and 1200 mm of rainfall annually. Woodlands and open forests of *Eucalyptus* spp. (*E. crebra, E. maculata, E. tereticornis, E. tessellaris*) occur in coastal and sub-coastal areas along the eastern seaboard from Cooktown to the Queensland-New South Wales border. Induced by management practices, *H.contortus* is the most characteristic species although *Bothriochloa bladhii* and *T. triandra* are dominant in some parts of the community.

While black spear grass occurs on almost all soil types, 70% of its area is confined to infertile texture contrast soils and earths. The remainder occurs on more fertile soils (duplex, loam, clay) and is thus subject to replacement by sown pasture species or crops.

Most areas in the south have been cleared to some extent, some extensively, by tree ringbarking and poisoning.

4. Queensland blue grass

Dichanthium sericeum grasslands occur on limited (2.4 m ha) areas of fertile cracking clays in southern (Darling Downs) and central (Central Highlands) Queensland. Rainfall averages between 600 mm and 700 mm a year.

Characteristic species in southern Queensland are *D.sericeum, D.affine* and *Aristida leptopoda,* while *Bothriochloa erianthoides, D. sericeum, D. affine, A. leptopoda, A. latifolia* and *Astrebla spp.* occur in the Central Highlands.

Much of this grassland community is cultivated for crops.

5. Brigalow pastures

Flat to gently undulating brigalow forests and open forests occupied 8.7 m ha of largely fertile, sometimes gilgaied heavy clays which occur to the west of the black spear grass in central and southern Queensland. The dominant tree in this area is *Acacia harpophylla,* which is associated with several other trees. *Casuarina cristata* is often co-dominant and on some soils it may be dominant. Although clearing by axe was started around 1900, accelerated development has only occurred over the past 40 years with the use of heavy machinery for land clearing.

Pasture species (*Paspalidium spp.*) were sparse before clearing. Following tree removal, and in the absence of species introduction, native pasture communities based on *Chloris, Paspalidium, Dichanthium, Sporobolus* and *Eragrostis* developed.

Sixty percent of brigalow pasture soils are uniform clays of moderate to good fertility. A further 27% are texture contrast soils of moderate fertility. Very high levels of production immediately following development have declined in brigalow pastures, but these pasture systems remain productive compared with other pasture systems in the State. Long-term land use trends in this native pasture community are towards greater areas of cultivation at the expense of sown and native pastures, especially on clay soils and in southern areas. The use of leucaena (*Leucaena leucocephala*) is providing a significant boost to animal production in the northern half of the zone.

6. Aristida-Bothriochloa pastures

This community is a composite of eight types in which either *Aristida* or *Bothriochloa* is prominent. It occupies 33.5 m ha of semi-arid woodlands which surround, and in places form a mosaic with brigalow in central and southern Queensland. It occurs as an unbroken community in north Queensland. Infertile earths, texture contrast and sandy soils comprise 89% of the area. In many pastures, *Aristida* has been a major increaser. Land use is predominantly sheep and cattle grazing at relatively low stocking rates, except in the Granite-Traprock area where rates are higher. The small proportion of better soils (11 per cent) have potential for forage cropping.

The component vegetation zones are:

• Western slopes of Einasleigh uplands: Woodlands of *E.microneura* developed on infertile sandy soils with *Aristida spp.* and *Chrysopogon fallax* prominent.

• Paperbarked tea-tree: *Melaleuca spp.* low woodlands occur on infertile earths and duplex soils with *Aristida spp.* and *C.fallax* as characteristic grasses. Low grazing pressures have left these pastures in good condition.

• Lancewood: *Acacia shirleyi* woodlands with a very sparse ground cover of *Triodia pungens* and *Aristida spp.* occupy dissected plateau areas with skeletal soils. The level of use is low.

• Dissected sandstone hills: A range of forest or woodland communities occur on dissected sandstone hills. *Eucalyptus spp.* form layered woodlands with grasses such as *Cymbopogon refractus, Aristida spp., Themeda triandra, Arundinella spp.* and *Triodia mitchellii.* Acacia open forests with *A.catenulata* and *A.shirleyi* have *Aristida caput-medusae, Cleistochloa subjuncea, Dimorphochloa rigida, Cymbopogon refractus* and *Arundinella spp.* as characteristic grasses. *Aristida* species increase with disturbance.

• Poplar box-mulga: Woodlands of *E.populnea* with an understorey of *Acacia aneura* and *Geijera parviflora*, sometimes *Eremophila mitchellii* occur on deep red earth plains. Grasses commonly encountered are *Aristida spp.* and *Thyridolepis mitchelliana.* Sheep and cattle grazing have promoted the increase of *Aristida* and probably contributed to increased densities of woody plants.

• Semi-arid woodland plains and low hills: Woodlands of *Eucalyptus populnea* and *Eremophila mitchellii* with *G. parviflora* develop on alluvial material and often associated with drainage lines. Soils are duplexes of moderate fertility. *Chloris spp.* are important grasses and with development and use *Bothriochloa* and *Aristida spp.* become prominent. Heavy sheep and cattle grazing in the past has promoted *Aristida* and probably contributed to increased densities of woody plants.

• Southern sandy country: There are two distinct community types contained in this vegetation zone. The first is the open forest of *Callitris columellaris* and *Casuarina leuhmannii* which occurs on infertile sandy duplex soils (solodics) and contains a native pasture of *Aristida* and *Eragrostis* as characteristic genera. The second is the temperate woodland community which extends northward from NSW into the southern Darling Downs and is locally known as the Granite-Traprock country. It contains a large range of *Eucalyptus* species. While sub-tropical woodland grasses such as *Bothriochloa decipiens* and *B.macra* occur, temperate grasses such as *Stipa scabra* and *Danthonia* spp. are also prominent.

• Cypress pine: Deep sandy duplex soils support *Callitris columellaris* woodlands with a variety of *Eucalyptus* spp. and sometimes with *Casuarina leuhmannii.* Native pastures are very sparse and contain *Aristida spp.* and *Cymbopogon refractus* as characteristic grasses. Densities of cypress pine have increased considerably in the absence of fire.

7. Gidgee pastures

A total area of 4.8 m ha probably underestimates the extent of gidgee (*Acacia cambagei*) and Georgina gidgee (*A.georginae*). As rainfall decreases, gidgee replaces brigalow on the heavier soils and scattered occurrences on the margins of both brigalow forests and *Astrebla* grasslands may not be recorded as distinct communities. Gidgee stands in the latter grasslands have increased in density and in area in recent decades. Georgina gidgee is restricted to north west Queensland.

Dense stands of *Acacia cambagei* in the central west had only a sparse ground flora until modified by land clearing. Subsequently, stands of *Cenchrus ciliaris* thrive on high available nitrogen and even in the long term appear well adapted. They supported greatly increased stocking rates of sheep and cattle. Characteristic native grasses are *B.ewartiana* and *Dichanthium affine* while *Astrebla spp. Eragrostis setifolia, E.parviflora* and *Chloris pectinate* occur in gidgee low open woodlands in the south-west. Woodland communities of *Acacia georginae* support species of the *Astrebla* grasslands.

While most commonly occurring on clay soils, gidgee pastures are also found on loams, earths and duplex soils.

8. Mulga pastures

The semiarid woodlands give way to mulga (*Acacia aneura*) woodlands and shrublands on the poorer and lighter soils. Both summer and winter rainfall appear necessary to maintain mulga and the plant is absent from semiarid regions with regular summer or winter drought. Structurally, mulga associations range from open forests to sparse tall open shrublands. They occupy 19.1 m ha of south-west and central western Queensland.

Characteristic genera are *Aristida, Thyridolepis, Eriachne, Digitaria* and *Eragrostis,* not necessarily occurring in the same communities. The presence of *Acacia aneura* as a drought fodder has been invaluable for the maintenance of stock but has contributed directly to the over utilisation of native pasture species.

Eighty per cent of soils are infertile earths, texture contrast soils or sands.

9. *Mitchell grass*

The *Astrebla* grasslands are the most extensive and the most valuable of Queensland's inland native pastures. They occupy an area of 29.5 m ha between the 250 mm and 500 mm isohyets. On suitable soils receiving less than 250 mm of rainfall in the far west, *Astrebla* occurs only during sequences of high rainfall years. These areas are more frequently occupied by chenopod herbfields. In flooded areas, *Eucalyptus coolibah* and *E.camaldulensis* fringe drainage lines.

Four species of *Astrebla (A.lappacea, A.elymoides, A.pectinata, A. squarrosa)* are widespread and occur as tussock grasslands of low basal cover (2 to 4%). The interspaces are occupied by a range of annual grasses and forbs (*Iseilema, Dactyloctenium, Brachyachne, Amaranthus, Salsola, Portulaca* species).

The *Astrebla* grasslands occur on heavy textured soils, 90% being cracking clay and the remainder fertile duplex soils. High temperatures and the lack of shade are husbandry problems. The spread of the introduced woody weed prickly acacia (*Acacia nilotica*) onto 6 million ha of these grasslands has led to serious management problems in northern areas. Other species causing similar concerns include mesquite (*Prosopis*) and parkinsonia (*Parkinsonia aculeata*), and the native mimosa (*Mimosa farnesiana*) (Reynolds and Carter 1993).

10. *Spinifex*

Triodia, Eriachne and *Zygochloa* are characteristic species of 21.2 m ha of poor quality hummock native pastures occurring as grasslands and under acacia and eucalypt (*Eucalyptus melanophloia, E.papuana, E.leucophloia*) woodlands. Soils are sands, loams and duplex soils and are consistently infertile.

Many spinifex pastures are grazed only in conjunction with better quality associated land systems. Alternatively, they are reserved for drought grazing with the aid of supplements.

11. *Channel country pastures*

The broad network of channels and enclosed flats of the Diamantina, Georgina and Bulloo Rivers and Cooper and Eyre Creeks form the channel country of the south-west. The area involved is 5.4 m ha of clay soils with *Eucalyptus microtheca* and *E.camaldulensis* fringing the main channels. *Muehlenbeckia cunninghamii* is associated with depressions.

Valuable forage appears after flooding of the channels and flats. The genera *Echinochloa, Chenopodium, Trigonella, Iseilema, Panicum, Sclerolaena, Dactyloctenium* and *Atriplex* are common depending on when flooding occurs.

12. *Blue grass-browntop*

The treeless plains of the lower Gulf of Carpentaria support 5.6 m ha of *Dichanthium fecundum-Eulalia aurea* grasslands. Associated genera are *Astrebla, Sorghum, Aristida, Chrysopogon* and *Iseilema.* The community occurs between the 500 mm and 800 mm isohyets and rain falls mainly in the summer. Cracking clays predominate but these differ from the fertile grey and brown clays of the *Astrebla* grasslands in their lower fertility and low percentage of plant available water capacity.

13. *Schizachyrium*

The lands of Cape York Peninsula are the least developed for pastoral use in the state. This is a reflection of the poor quality of the available forage.

Ground cover species vary throughout the area. The most widespread community is *Eucalyptus tetrodonta* open forest which supports *Heteropogon triticeus, Schizachyrium fragile, Panicum mindanaense* and *Eriachne stipacea.*

In the central north, woodlands of *E. tetrodonta* support *Sorghum plumosum* pastures while *H.triticeus, Rhynchospora longisetis, Pseudopogonantherum contortum* and *Bothriochloa bladhii* occur but are less abundant.

Melaleuca viridiflora is conspicuous in the lower tree stratum in some forests and woodlands and is the dominant tree species in low open-woodlands on the western peninsula. In this community the bulk of the ground cover consists of annual grasses (*Aristida spp., Eriachne burkittii, Schizachyrium spp.* and *Ischaemum baileyi*).

Low eucalypt woodlands on the eastern peninsula have ground cover of either *H.triticeus, E.glauca, S.fragile* and *Thaumastochloa spp.* or *H.triticeus* and *Sorghum plumosum.* The heath communities of the north-east have *Schoenus sparteus* as the common ground species.

More than 90% of soils are infertile earths, duplex soils, sands and loams.

14. *Native sorghum*

Extending over 1.0M ha of *E. tetrodonta* woodlands in the northern part of Cape York the native sorghum community provides one of the better grazing lands of the Peninsula. Rainfall of 1200 mm a year is reliable.

Sorghum plumosum is the common grass species though *H.triticeus, Rhynchospora longisetis, Pseudopogonantherum contortum* and *Bothriochloa bladhii* occur but are less abundant.

APPENDIX 3: ASSESSMENT OF PROPERTY VALUES IN CENTRAL QUEENSLAND

This section reports the market response to the Tree Clearing Guidelines in the Central Highlands/Desert Uplands region. The identification of properties has been withheld.

Property 1.

Description:

. About 20 000 hectares near Clermont in the Belyando/Suttor River region;

. Some 3000 ha are developed, carrying some 1900 head.

. Some 14 000 to 16 000 ha can be developed, with a resultant carrying capacity of 3500 head.

. The anticipated market value (fully developed) is approximately $150-$160/ha.

. Prior to the introduction of the Draft State Guidelines the property was listed for sale at $100/ha. An offer of $86.50/ha was received but rejected.

. Recently sold at auction for $1.45 million ($75/ha) to an adjoining owner.

However, development of the virgin country is now severely restricted by the Draft State Guidelines which limit development of the brigalow, yellowwood and gidgee communities. Under current guidelines, development is restricted to between 0-20% of these land types.

The marketing agents report that the property was inspected by no less than ten interested parties prior to auction, but they lost interest when the effects of the guidelines were explained. The agents consider that the property would not have sold except for the special circumstances which existed with the adjoining owner who ultimately purchased.

Summary:

The sale price ($75.50/ha) was fair market value for the property given its current carrying capacity and restricted development potential. However, a market value of $90-$95/ha would have been considered fair, prior to the announcement of the guidelines.

In this case, a discounted market value of some 15-20% is evident due to the uncertainty created by the guidelines. Further, the effects of the guidelines on the market had less impact due to the open nature of the timber on this property.

Property 2.

Description:

. About 8 000 ha near Alpha (Zone 6).

. Some 400 ha developed, carrying some 300 head.

. Balance of property dense brigalow with patches of box.

. Tree Management Plan prepared, allowing 20% retention of all tree associations.

. The property was purchased on the basis that 80% could be developed and once assurances had been received, the property was sold (December 1993 for $536500 - $65/ha).

. Fully developed, the property will now carry some 1 500 head and would command a market value of $150-$175/ha.

However, had the Draft State Guidelines been introduced prior to the development of this property, then the 80% retention factor for Zone 6 would have applied, and based on sales evidence of comparable blocks, it is considered that the market value would not have exceeded $20/ha, and would have been unsaleable.

In effect, it is considered that the draft guidelines would have led to a reduction of 70% in the value of this property.

Note that for this property, the carrying capacity of the brigalow scrubs in their natural state is negligible (~ 1/40ha).

Property 3.

Description:

. A forest block of 24 600 ha situated in the Desert Uplands (Zone 3); comprises silverleaf ironbark and box country with wilga, small patches of brigalow and in the main some spinifex understorey running to poor yellowjacket, heartleaf country with patches of lancewood and bendee.

. Approximately 4000 ha have been developed, carrying some 1000 head.

. Some 16 000 ha are suited to development.

. Listed for sale at $32 per hectare.

. Interest in the property was very strong prior to the announcement of the Draft State Guidelines which effectively allow for between 0-10% for further development.

Marketing agents consider this property is now virtually unsaleable unless the price is dropped. There is absolutely no purchaser interest in the property, and the property has now been withdrawn from sale.

Prior to the announcement of the Draft State Guidelines, a value of $32/ha would have been considered slightly below the market for this type of country.

Property 4.

Description:

. Some 34 600 ha situated on the Drummond Range, to the south west of Emerald (Zone 6).

. Mainly range country but has approximately 10 000 ha of mixed brigalow scrub and forest suitable for development.

. Has a current permit to develop 9000 ha which expires in September 1996. The permit is not transferable and the current lessee does not have the financial capacity to carry out the development.

. Listed for sale, however no interest once buyers realise the permit is not transferable.

. The financial institutions are not prepared to lend money based on what was considered to be fair market value of the property before the guidelines were announced. They are prepared to assess the current market value at 50% of its previous value.

It is considered that the property is not saleable without a reduction of 40-50% in the vendor's asking price.

APPENDIX 4: SCIENTIFIC AND COMMON NAMES

Scientific Name -Common name

Acacia aneura	mulga
A. cambagei	gidgee
A. catenulata	bendee
A. farnesiana	native mimosa
A. georginae	georgina gidgee
A. harpophylla	brigalow
A. nilotica	prickly acacia
A. shirleyi	lancewood
Albizzia lebbeck	Indian cirrus
Amaranthus	an amaranth
Arundinella	reed grass
Aristida caput-medusae	wiregrass
A. latifolia	feathertop
A. leptopoda	white spear grass
Astrebla elymoides	hoop mitchell grass
A. lappacea	curly mitchell grass
A. pectinata	barley mitchell grass
A. squarrosa	bull mitchell grass
Atriplex	a saltbush
Axonopus affinis	a carpet grass
Bothriochloa bladhii	forest blue grass
B. decipiens	pitted blue grass
B. erianthoides	satin top
B. ewartiana	desert blue grass
B. macra	redleg grass
Brachyachne	native couch
Callitris columellaris	cypress pine
Casuarina cristata	belah
C. leuhmanii	bull oak
Cenchrus ciliaris	buffel grass
Chenopodium	blue bush
Chloris pectinata	comb chloris
Chrysopogon fallax	golden beard grass
Cleistochloa subjuncea	
Cymbopogon refractus	barbed wire grass
Dactyloctenium	button grass
Danthonia	wallaby grass
Dichanthium affine	slender blue grass
D. sericeum	Qld blue grass
D. fecundum	gulf blue grass
Digitaria	summer grass
Dimorphochloia rigida	
Echinochloa	a millet
Eragrostis parviflora	weeping love grass
E. setifolia	neverfail grass
Eremophila mitchellii	false sandalwood
Eriachne burkittii	
E. stipacea	
Eucalyptus camaldulensis	river red gum
E. cambageana	Dawson gum
E. coolibah	coolibah
E. crebra	narrow leaf ironbark
E. erythrophloia	pink bloodwood
E. glauca	
E. grandis	flooded gum
E. maculata	spotted gum
E. microneura	Georgetown box
E. melanophloia	silver leaf ironbark
E. papuana	ghost gum
E. platyphylla	poplar gum
E. polycarpa	longfruited bloodwood
E. signata	
E. tereticornis	blue gum
E. tessellaris	Moreton Bay ash
Eulalia aurea	silky brown top
Geijera parviflora	wilga
Heteropogon contortus	black spear grass
H. triticeus	giant spear grass
Imperata cylindrica	blady grass
Ischaemum baileyi	
Iseilema	Flinders grass
Leucaena leucocephala	leucaena
Melaleuca viridiflora	tea tree
Melinis minutiflora	molasses grass
Muehlenbeckia cunninghamii	lignum
Panicum mindanaense	a panic
Parkinsonia aculeata	parkinsonia
Paspalidium	brigalow grass
Paspalum dilatatum	paspalum
P. notatum	Bahia grass
Pennisetum clandestinum	kikuyu
Portulaca	pigweed
Prosopis	mesquite
Pseudogonantherum contortum	
Rhynchospora longisetis	
Salsola	rolypoly
Schizachrium fragile	firegrass
Schoemus sparteus	
Sclerolaena	a burr

Setaria	setaria
Sorghum plumosum	plume sorghum
Spinifex hirsutus	beach spinifex
Sporobolus virginicus	marine couch
Stipa scabra	rough spear grass
Thaumastochloa	
Themeda triandra	kangaroo grass
Thyridolepis mitchelliana	mulga mitchell
Trigonella	fenugreek
Triodia pungens	soft spinifex
T. mitchellii	black spinifex
Ziziphus mauritiana	chinee apple
Zygochloa	sandhill canegrass