Sustainable primary production in the Burnett Mary Region

Technical Paper

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The Department of Primary Industries and Fisheries (DPI&F) seeks to maximise the economic potential of Queensland's primary industries on a sustainable basis.

SUSTAINABLE PRIMARY PRODUCTION

IN THE BURNETT MARY REGION

TECHNICAL PAPER

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by
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1.0 CURRENT RESOURCE STATUS

1.1 INTRODUCTION

The national and international community and government at all levels are increasingly focussing on the off-site impacts of agriculture. Cropping and grazing are considered to be the primary sources of chemical, nutrient and sediment inflow into the Great Barrier Reef Lagoon and the Great Sandy Straits. Poorly managed intensive livestock production can potentially result in contamination of ground and surface waters. However, there are difficulties in linking multiple and diffuse sources of pollution with sub-catchment level impacts. Developing landscape-wide approaches to sustainable production programs through Regional NRM partnerships is a key response to this situation.

The increasing cost of water, and recognition that available supplies may not meet future demand for food and fibre production, has resulted in programs seeking to optimise water usage. Vegetation loss is now a serious matter with severe salinisation of agricultural and urban lands likely to lead to long-term economic impacts if we are unable to halt and reverse these trends. Community concern over logging native forests has resulted in the need for rapid scientific advances in timber production to achieve early economic returns from high-value hardwood plantations. The issue of the migration of pesticides into natural systems and food chains is entering the broad public debate. These rapid changes in the operating environment of agriculture have driven a need to invest in sound research and development to achieve ecologically and economically efficient practices.

The tenacity and adaptability of primary producers is demonstrated by the continued strong role agriculture and fisheries play in the regional economy. Agriculture, forestry and fisheries industries still provide an average of 26% of employment in the region (excluding Sunshine Coast Councils areas) and up to 54% of the workforce in the Munduberra Shire (See Appendix I). Ensuring this employment is sustainable in the long term would be a high value investment in the economic stability and environmental prosperity of the Burnett Mary Region. The 2001 Agricultural Census of shires within the region (including some of the SEQ region) recorded nearly $63 million worth of production, which was approximately a 9% increase from the 96/97 census (see Appendices I, II and III for Industry and Shire data).

The government is increasingly calling for land managers to demonstrate a “duty of care” as stewards of the landscapes they use for primary production. However, sustainable production systems are inherently complex, particularly considering the fact that degradation of land and water resources is a relatively slow incremental process and varies with the biophysical characteristics of particular landscapes and the nature of the production. The impact of both poor management practices and the efforts to rehabilitate in these slowly evolving systems can take decades if not centuries to become apparent at a landscape level. Therefore, developing monitoring systems that can provide early warnings of potential problems is a core component of sustainable production.

While some consider statutory controls alone can achieve sustainability in production systems few stakeholders who are aware of the dynamics of ecosystems, agricultural communities and production systems would agree. Setting statutory environmental standards for regulated intensive agricultural activities is feasible due to the ability to readily monitor point source pollution. However, implementing actions that achieve the voluntary adoption of practices

which result in ecologically sustainable resource use, is an essential ingredient in any strategy to increase sustainable primary production. The key to achieving ecologically sustainable primary production is to develop and implement systems that not only minimise environmental harm, but also increase productivity, profitability and contribute to desirable social outcomes for the whole community.

1.2 LAND MANAGEMENT IMPACTS

1.2.1 Impacts of Forestry Practice on Water Quality and Groundwater Hydrology

The impacts of forestry practices on ecological processes depend on the type, intensity and scale of operations and this is quite variable. Forest harvesting can be a major disturbance to water quality and quantity where poor management practice is adopted. However, the low intensity harvesting practiced over most of both catchments is unlikely to cause significant disturbance to either terrestrial or aquatic ecology with basic environmental protection guidelines in place. These are outlined in the Code of practice for native forest timber production. (EPA 2002). A similar code exists for plantations although both are only mandatory on crown land and not private tenure. Studies on the impacts on water quality and yield from 'best practice' exotic pine plantation management indicate that water yield is increased in streams after clearfelling (Bubb and Croton 2002, Costantini *et al* 1997). However, there were no observable effects on water quality from applied best practice management and the relative impacts on water quality ranked as the lowest in comparison to other land uses.

1.2.2 Remnant and Riparian Vegetation

Surveys carried out in the early 1980s showed that tree dieback in remnants on farmland and along streams was widespread and severe in several shires such as Kilkivan, Tiaro, Cooloola, Eidsvold and Monto, and of light to moderate severity in most other Shires. The main riparian tree species being affected were river sheoak (*Casuarina cunninghamiana*) and forest red gum (*Eucalyptus tereticornis*), while other key remnant species commonly showing dieback included narrow-leaved red ironbark (*E. crebra*), grey ironbark (*E. drepanophylla*), spotted gum (*Corymbia citriodora ssp. variegata and C. citriodora ssp. citriodora*) and silver-leaved ironbark (*E. melanophloia*). While these surveys have not continued, links between land-use impact, salinity and forest health are considered to be a significant ingoing issue for the region.

1.2.3 Grazing Land Resource Condition

The major pasture community in the Burnett Mary is the southern black speargrass zone (Weston *et al.* 1981). The blady grass zone occupies the high-rainfall coastal areas. Some minor brigalow communities and *Aristida/ Bothriochloa* communities exist in the inland and western Burnett. Tothill and Gillies (1992) reported on the condition of north Australia's grazing land. In summary for the southern speargrass zone:

- 20% was in a sustainable condition
- 60% deteriorating state; and
- 20% degraded state;

and the southern blady grass zone:

- 10% was in a sustainable condition
- 75% deteriorating state; and
- 15% degraded state.

A fall in land condition results in reduced pasture productivity (reduced rainfall use efficiency) and livestock performance (reduced carrying capacity and diet quality). It also has negative impacts on water quality (due to increased soil and nutrient loss) and biodiversity (particularly floristic changes and accompanying changes in micro and macro fauna dynamics). Changes in land condition (both negative and positive) are a function of grazing land management; in particular:

- Grazing management (matching stock numbers with carrying capacity and temporal and spatial distribution of grazing)
- Use of fire (timing, frequency and intensity)
- Woodland management (woodland thickening, thinning, clearing and conservation)
- Sown pasture development (appropriate land type development, species selection and management)
- Weed management (appropriate planning, prevention, containment and control)

1.2.4 Quality of Water Supplied to and Leaving Farms

In the Mary catchment, water quality issues in streams providing irrigation supplies are chronic in a number of waterways and acute during dry periods when reduced flows affect irrigation management and can result in salt build-up in soils (Stockwell 2001). Faecal coliform problems have required horticultural and hydroponic producers to fit expensive filtration systems to ensure irrigation water meets quality assurance standards. Dairies in the Obi Obi catchment have also reported problems in this regard. Stream salinities in excess of that recommended for sensitive plants (<0.65 dSm^{-1}) and moderately sensitive plants (0.65-1.3 dSm^{-1}) have been recorded in a range of locations throughout the catchment for over two decades (Bevege and Simpson 1981 in Lamb 1986, Johnston and Wylie 1984, Buhle 1991, Pusey *et al.* 1993, Wylie *et al.* $1993_{(b)}$, Stockwell 1996, Stockwell 2001). Salinity levels recorded in the lower and middle sections of the catchment are at a level in excess of that recommended for even moderately tolerant crops (1.31-2.90 dSm^{-1}) (pers. comm. MRCCC 2004, Waterwatch data). The main sub-catchments of concern in relation to stream salinity are:

- Lower Tinana and tributaries – high reading – 6.5 dSm^{-1}
- Gutchy Creek and surrounding areas - high reading- 3.2 dSm^{-1}
- Glastonbury Creek – high reading 2.4 dSm^{-1}
- Calico Creek – high reading 1.7 dSm^{-1}
- Pie Creek – high reading 1.6 dSm^{-1}
- Kybong Area – high reading 1.6 dSm^{-1}
- Widgee Creek – range 1.3 – 3.0 dSm^{-1}
- Deep Creek and Sandy Creek –range 1.3 – 3.0 dSm^{-1}
- Munna and Wide Bay Creeks - range 1.3 – 3.0 dSm^{-1}

Issues affecting the rest of the region include (pers. comm. NR&M Bundaberg 2003):

- Gregory River has a number of local salty small streams such as Stockyard Creek and irrigation supplies will potentially become increasingly saline;

- Isis River potentially has local salinity on red soil margins;
- Medium to high stream salinity at low flow in Byee area, Barker Ck, Stuart River, upper Boyne River and Boondooma Ck (particularly from red soils);
- Medium to high stream salinity recorded at low flow Three Moon Creek but this may be result of groundwater springs;
- Coastal groundwater is a significant issue (saltwater intrusion). The Elliott formation is the largest aquifer with over 1.5 million ML capacity. However, only 55,000 ML is above sea level so over-use is potentially high-risk.

There are few data identifying catchment scale issues with downstream water quality linked to horticulture practices. However, subcatchments where a potential exists for nutrient and sediment runoff include (pers. comm. NR&M Bundaberg):

- Byee Irrigation Area is perhaps the horticultural floodplain area in the Burnett of high risk, but it is likely to be very localised considering the limited extent of horticulture.
- Within the Mary irrigation scheme areas, mainly in the Upper Scheme (Borumba to Pie Ck),
- Soil Salinity is an issue in all coastal regions but can be managed on a farm scale.
- Saline water tables are present close to the surface in Hervey Bay, Susan River, Walkers Point to Beaver Rock Road areas.
- Groundwater in inland regions is of some complexity, but generally localised with on-farm management to limit the disturbance of water balance.

1.2.5 Pesticides and Chemicals Entering the Environment

Spray drift is a social issue near urban areas. There are no local data identifying environmental impacts, and drift is not a significant issue in most of the Burnett and Mary catchments. The Gayndah -Munduberra and Bundaberg- Childers areas are the most likely 'hot spots' in the Burnett. The upper Mary potentially could experience problems, considering the extent of agriculture near to urban and rural residential development.

Studies in the Bundaberg area have shown the microbial activity in soils used predominantly for vegetable crops to be significantly lower than soils used predominantly for sugarcane or native vegetation (Hoong Pung 2003). These data also suggest that Bundaberg vegetable growing soils are amongst the most biologically inert soils that are cropped in Australia. It is predicted the main contributor to this is likely to be the higher use of fumigants and chemicals to control pests/disease/weeds, as well as the higher cultivation rates for soil structure and bed preparation (Stirling 2004).

The expansion of ley cropping in coastal sugar cane country has led to high cadmium concentrations in soils associated with the traditional high use of phosphatic fertiliser, in which cadmium is an impurity (Rayment 1997, Bramley *et al.* 1996). Cadmium concentrations exceed the maximum permissible limits in some crops around Bundaberg as a result of bioaccumulation in acidic, lighter-texture soils (Bell *et al.* 1997). A range of management strategies including more frequent irrigation and the addition of a combination of lime, zinc, potassium sulfate and cane trash and have been shown to be successful in reducing the availability of cadmium (Bell *et al.* 2001b).

1.2.6 Efficient Use of Limited Water Resources

The Rural Water Use Efficiency Program has seen major initiatives that target the maximum productive use of existing irrigation supplies (Barraclough and Co. 1999). In the Burnett/Mary region, it is estimated that more than 740 fruit and vegetable growers have made water savings of approximately 4790ML; with total dollar value of water savings and related productivity gains valued at approximately $28million. The adoption of Best Management Practice (BMP) by fruit and vegetable growers in the region ranges from 28% (Mary) to 74% (Gayndah/Munduberra), compared to the state-wide average figure of 45%. The financial incentive schemes in the region have attracted 819 applications with 583 approved. Queensland Fruit and Vegetable Grower's 'Water for Profit' program estimates that state-wide on-farm use in Horticulture is ~ 260,000 ML, a saving of ~ 4% since 1989. A similar water use efficiency program exists in the sugar industry. Despite the high uptake of water use efficiency strategies, there are still some operations that irrigate on a calendar basis rather than crop needs. Shortage of irrigation water in most of the coastal irrigation areas means that sugarcane will be irrigated on a cyclical basis rather than crop needs basis, as scheduled need can not be met in below-average rainfall periods.

1.2.7 Horticultural Waste Management

Use of Agricultural Plastics is growing at a rate of around 10% p.a. with approximately 60,000 tonnes being the total market in 1999. Use of polymers in agriculture has grown 70% between 1994 and 1999. It is estimated land under cultivation using 'plasticulture' in Bundaberg region is approximately 4800 ha The potential supply of recycled polyethylene (P.E.) to the market from the Bundaberg region is 1,000 tonnes p.a. (3% of total used in agriculture). Approximately 590 tonnes of plastic mulch and 270 tonnes trickle tape is sold annually in the Bundaberg and surrounding shires (Burnett, Kolan, Isis) (Cunningham and Whitwell 2001). A survey has shown that growers indicate over 60% of plastic waste is disposed of in landfills, the remainder is disposed of on-farm (burial, incineration, ploughing into soil). Recycling of mulch plastic has commenced with a mobile facility developed by T-Systems Australia.

1.2.8 Reduced Soil Health

Soil erosion is a medium to high risk across the region. Other risks to soil health in the region include reduced organic matter, poor soil structure, nutrient deficiency and low levels of microbial activity. Poor soil health leads to increased fertilizer application, increased chemical use, increased pest incursions as well as increased soil loss. Soil structure and low organic matter (OM) are existing or potential problems, particularly in silty soils along rivers in the lower Burnett, Kolan, upper Burnett, lower and upper Mary irrigation schemes. Decline in the concentration of OM in the top 30 cm of cropped ferrosols (red soils) is considered to be one of the most significant changes in the Inland Burnett (Bell *et al.* 1998). Together with nutrient deficiencies the OM decline associated continuous cropping has resulted in significant reduction in crop growth (50-100%; Bell *et al.* 1998)

If appropriate management is introduced, the problem reduces in intensity. Bell *et al.* (1998) have demonstrated that Kikuya (*Pennisetum clandestinum*) and Rhodes grass (*Chloris gayana*) pasture leys can dramatically improve soil organic matter. Similarly, the increasing adoption of green cane harvesting and residue retention in the region is resulting in improvements in soil OM and is reducing the potential for sediment loss and surface crusting. Pasture breaks and legume fallows in cane systems have also been found to increase organic carbon and soil fertility (Moody *et al.* 1999)

Bell *et al*. (2001a) have shown that production benefits flowing from reduced surface crusting in trash blanket systems were limited by soil compaction resulting from heavy trafficking during harvesting. Structural decline is especially significant in soils with high levels of fine sand due to compaction and surface sealing. This is particularly a problem when over-head spray irrigation is used as a result of droplet impact. There are also structural decline implications in all soils with no shrinking/ swelling characteristics, and low OM issues in all soils.

There is a suite of coastal, highly weathered, highly permeable soils which are extremely nutrient deficient. Low nitrogen mineralisation is associated with low OM in coastal areas. Soil acidity is a particularly important issue in highly weathered coastal soils, which have a naturally acid pH (being sandy, highly permeable and with a variable charge). However, there are significant areas of the coastal Bundaberg irrigation area, particularly horticultural soils, that have neutral pH and some are slightly alkaline (pers. comm. Kinston BSES Bundaberg 2004). Inland soils, however, are better buffered and hence less impacted by salinity. Acid sulphate soils are located in the lower Burnett/Kolan and Elliott catchments, and in the lower Mary irrigation scheme. If drained or disturbed and aerated, a significant reduction in pH leads to the release of sulphuric acid and heavy metals into waterways and wetlands.

Low levels of microbial activity is a severe problem in many of the soils, and is likely to become more extreme as area-based productivity increases and the area of land used for horticulture increases, if no viable soil productivity options are researched and implemented.

1.2.9 Erosion from Cropping Land

By the 1950s soil erosion was seriously threatening the productivity of fertile cropping areas such as the inland Burnett. Of the area cultivated in Queensland, around 80% is susceptible to soil erosion. Soil losses can be very high if no appropriate preventative measures are taken.
Erosion can affect on-farm productivity and result in loss of infrastructure (roads, fences). Downstream impacts can also be severe through the movement and deposition of sediment and the associated carriage of nutrients (phosphorous and nitrogen) and agricultural chemicals.

Brodie *et al*. (2003) produced models that identified soil erosion as the dominant process supplying 63% of sediment to the rivers. This modelling has been able to identify and predict priority areas for soil loss in the Reef catchments and has identified the Burnett Mary as high priority for management to reduce sediment and nutrient export. While surpassed by the Mackay Whitsunday coast including the eastern parts of the Fitzroy and Burdekin river basins, the Burnett Mary was identified as being responsible for a moderate delivery of sediment from soil erosion, gully erosion, and bank erosion.

1.2.10 Dryland Salinity

“In the Burnett catchment rising groundwater and salinity is a major problem that threatens the productivity of the region. This water balance problem has resulted from the inability of crop and pasture species to transpire as much water as the native vegetation they replaced” (Claridge *et al.* 2001). The growing adoption of minimum till and direct drill systems to improve rainfall infiltration and reduce erosion risk has also increased dryland salinity risk in cropping lands (Bell *et al*. 2003a). This research has shown that increased deep drainage is linked to poor water holding capacities and rapid rates of internal drainage.

Modelling shows that ground water contents are highest in both steep gullies and lower slopes where there is a large contributing area, particularly where convergence or large restrictions occur (Claridge *et al.* 2001). A comparison of recharge under six different land use scenarios found that the present land use pattern with a fixed crop rotation using a winter fallow was the leakiest system (poorest performing in terms of water balance). The model shows there would be little difference in water balance between the present land use and the conversion of the catchment to pasture. Establishing eucalypt plantations over the whole catchment, on the other hand, would allow the least recharge.

Selective use of farm forestry in key parts of the catchment is being investigated as a component of commercial farming systems to improve the hydrological balance and reduce the salinity risks associated with conservation tillage and other current cropping systems (Bell *et al.* 2003b).

1.2.11 Riparian Zone Management

Poor riparian zone management occurs throughout the region and can result in loss of agricultural land, sedimentation of waterways and poor buffering of agricultural pollutants associated with cane growing, cropping, horticulture and dairying including. Common practices which lead to a reduction in the asset value of riparian areas, waterways and wetlands include:

- existing horticulture/cropping systems in riparian zones that feature only shallow rooted plants rather than complex deep rooted forests, allowing streambanks to erode,
- existing horticultural/cropping systems in riparian zones with inadequate ground cover at certain periods of the year, allowing surface erosion from the zone itself and/or reducing filtering services from the rest of the property resulting in fertilisers, herbicides, nutrients and sediments entering waterways, and
- the use of riparian strips for headlands, roads and tracks rather than vegetation.

1.2.12 Nitrates in the Root Zone

The Intergovernmental Science Panel (2003) on the GBR Water Quality Protection Plan found evidence of a significant build up of nitrate below the root zone in highly weathered soils in the Burnett, generally in horticultural and sugar cane areas. Approximately 500 kg/ha of nitrate has been found to occur between 1 m and 3.5 m below the surface of a Bundaberg cane field, compared with little nitrate at the same depths on unfertilised land. At present however, there is no certainty to what extent this ‘sink’ will overflow into adjacent waterways, nor how long it may take.

1.2.13 Dairy Effluent Management

Dairying systems distribute manure around the farm with a number of areas of concentrated deposition (see Appendix III). One of the main areas of manure deposition is in the milking shed and on the associated concrete yards where cows are held prior to the (generally) twice daily milking. This manure is generally hosed or flushed into some form of effluent management system. Properly designed pond systems allow effluent to be stored until the soil dries out sufficiently to allow effluent irrigation onto crop or pasture to commence. The main areas were failure exist include:

- Effluent sumps generally only have sufficient capacity to store one or two days dairy wash-down water; effluent is inevitably irrigated onto wet ground during extended wet periods; Physical limitations and failure to move sprinklers and hoses on a regular

basis often results in effluent distribution over a limited area and subsequent nutrient overloading. This can result in nutrient-rich runoff entering watercourses and contaminants leaching below the crop/pasture root zone and potentially into groundwater aquifers.

- "Green snakes" that meander down the hillside promoting gravity discharge of effluent to paddocks provide little scope for managing effluent application. If the discharge point is close to a watercourse, under wet conditions, infiltration into the soil is minimal and the risk of contaminated runoff reaching surface water is increased. Soils in the discharge area are likely to be overloaded with nutrients, resulting in nutrient rich runoff and leaching of contaminants below the crop/pasture root zone and potentially into groundwater resources.

Dairy farms are commonly located along major watercourses within the region. Consequently, management of riparian land is an important issue for dairy farmers. Nutrient export to watercourses can be significantly reduced by providing vegetated buffers between intensively farmed areas and watercourses. Stream bank degradation is a major concern particularly in the Mary catchment.

1.3 *TERRESTRIAL WEEDS*

1.3.1 Overview of Weeds and their Impact on Production Systems

Sustainable land use requires natural ecosystem functions to be retained to prevent natural resource degradation. Weeds potentially alter ecosystem function adversely, reduce primary industry productivity and profitability, and seriously limit the long-term sustainability of the State's agricultural and natural resources. Terrestrial weeds are land based while aquatic weeds are generally water based. The only exception in the region is alligator weed, which can be both terrestrial and aquatic. Terrestrial weeds can be categorised into five plant life form groups – grasses, herbs, woody shrubs, trees and vines. The region's major pest plants are drawn from all five of these groups.

1.3.2 Extent and Importance

The major primary industries in the Burnett-Mary region are beef, forestry (native and plantation), horticulture, field crops (grain, oilseed, hay crops, fibre and sugar), dairy, intensive livestock (pigs, poultry and cattle feedlots) and aquaculture. The impact rating of terrestrial weeds on the sustainability production of these primary industries is as follows:

- Beef and forestry – *high impact*
- Dairy *moderate impact*
- Field crops and horticulture *low impact*
- Intensive livestock and aquaculture *not applicable*

In addition to the disturbance to ecosystems and potential loss of biodiversity, weeds impact on sustainable primary production in several other ways:

- reduced in animal production due to the invasion and degradation of pasture resources (eg groundsel bush and lantana)
- reduced animal production caused by pasture dominance by unpalatable weed grasses (eg giant rats tail grass)
- increased costs of production incurred in the control of weeds (eg herbicide use and labour costs)

- increased costs of production in preventing weed seed spread (eg machinery clean-down and stock quarantine)
- reduced value of production caused by weed/weed seed contamination of produce (eg hay and grain)
- increased cost of production in removing viny weeds from forestry timber or orchard trees (eg cats claw vine)
- loss in production from poisoning of livestock (eg fireweed and mother of millions)
- increased mustering costs of livestock caused by thickets of woody weeds (eg prickly acacia and lantana)
- reduced livestock production caused by the impeded stock access to creeks for water (eg rubber vine)
- negative effects on landholder and community health (eg parthenium and annual ragweed)

Over the past decade, numerous industry group and NRM community group stakeholder forums in the Burnett-Mary region have rated the impact of terrestrial weeds as a very high priority issue for both sustainable primary production and biodiversity values. Considering the above criteria the following ten weed plants are considered to have the highest priority, in terms of importance to production systems in the region:

- Lantana *(Lantana camara)*
- Giant rats tail grass *(Sporobolus pyramidalis* and *S. natalensis)*
- Groundsel bush *(Baccharis halimifolia)*
- Cats claw vine *(Macfadyena unguis-cati)*
- Parthenium weed *(Parthenium hysterophorus)*
- Mother of millions *(Bryophyllum spp)*
- Annual ragweed *(Ambrosia artemisifolia)*
- Rubber vine *(Cryptostegia grandiflora)*
- Prickly acacia *(Acacia nilotica)*
- Fireweed *(Senecio madagascariensis)*

Details of each of these species, their potential to spread and their importance to agriculture are outlined in Appendix IV.

The above prioritisation does not take into account threats from riparian weeds. The State of the Rivers Report for the Mary River and Major Tributaries (Johnson 1997) identifies an average of 22% of total riparian species were exotic plants (terrestrial weeds). The major exotic species listed were grouped into grasses, herbs, shrubs and vines (cat's claw vine, rhodes grass, lantana, milky weeds, burr spp and groundsel); and into exotic tree species (wild tobacco, castor oil, camphor laurel, Chinese celtis, privet, pepper tree and guava). Exotic plants (terrestrial weeds) were recorded at 82% of sites surveyed in the State of the Rivers for the Burnett River and Major Tributaries (Department of Natural Resources 1999). The major species listed were lantana, cat's claw vine, noogoora burr, prickly pear, balloon vine, balloon cottonbush, groundsel bush, mother of millions, thistle spp, Chinese celtis, rubber vine, camphor laurel, and privet (listed in order of frequency). Exotic plants (terrestrial weeds) were identified at 56% of survey sites in the State of the Rivers of the Baffle Creek and Major Tributaries (NR&M 2003). The major species listed were lantana, noogoora burr, milky weeds, thistle spp, exotic pines, devil's fig, cat's claw vine, red-head cottonbush and Mexican poppy (listed in order of frequency).

1.3.3 Condition and Trends

The Annual Pest Assessment (APA) grid map (Pestinfo: Department of Natural Resources and Minds) is a compilation of data from council weed inspectors and are the best available data from which to determine significant priority weed locations (Table 1.1).

Table 1.1 Regional locations of priority weeds

Weed species	**Hot spots in region**
Lantana spp	Upper Mary Catchment, Biggenden, and coastal Burnett north from Bundaberg.
Giant rats tail grass	Upper Mary Catchment, Gympie district, Murgon and all of coastal Burnett.
Parthenium weed	Gympie, Kingaroy, Murgon and Gayndah, plus most of the inland North Burnett Catchment, Upper Mary Catchment.
Groundsel bush	Eastern, Upper and Middle Mary Catchment, and most of the coastal Burnett Catchment
Fireweed	Upper Mary Catchment and Gympie district
Mother of millions	Burnett Catchment excluding parts of the South Burnett Catchment, Gympie District.
Annual ragweed	Middle and Upper Mary Catchment, coastal Burnett and west to Gayndah and Monto
Cat's claw vine	Mapping underway
Prickly acacia	Biggenden and Gayndah districts
Rubber vine	Parts of the Kolan Rivers, and parts of the coastal and north Burnett Catchments

Potential trends (Table 1.2) are evaluated for the Priority Weed Species for the region in terms of their potential for further spread/thickening; current impact on sustainable primary production and predicted future impact on sustainable primary production.

Table 1.2. A priority ranking for weed species according to their potential to spread and impact on primary production.

Priority Weed Species (in alphabetical order)	**Potential for further Spread and/or Thickening** (in descending order**)**	**Current Impact on Sustainable Primary Production** (in descending order)	**Predicted Future Impact on Sustainable Primary Production** (in descending order)
Annual ragweed (class 2)	1.Giant rats tail grass	1. Lantana spp	1. Giant rats tail grass
Cats-claw vine (class 3)	2. Cats claw vine	2. Giant rats tail grass	2. Lantana spp
Fireweed (class 2)	3. Lantana species	3. Parthenium	3. Fireweed
Giant rats tail grass (class 2)	4. Parthenium	4. Groundsel	4. Parthenium
Groundsel bush (class 2)	5. Fireweed	5. Mother of millions	5. Annual ragweed
Lantana species (class 3) (incl creeping lantana)	6. Annual ragweed	6. Annual ragweed	6. Mother of millions
Mother of Millions (class 2)	7. Groundsel	7. Rubber vine	7. Groundsel
Parthenium (class 2)	8. Mother of millions	8. Prickly acacia	8. Rubber vine
Prickly acacia (class 2)	8. African lovegrass	9. Fireweed	8. Prickly acacia
Rubber vine (class 2)	10. Rubber vine 11. Prickly acacia	9. Cats-claw vine	8. Cats-claw vine

2.0 - PRESSURES AND RISKS - – KEY REGIONAL THREATS

2.1 PRODUCTION PRACTICES

2.1.1 Tree Clearing and Maintenance of Ecosystems

The loss of further forest area within the region is limited by the Vegetation Management Act (1999) and loss of large areas of forest area in the future is unlikely. However, fragmentation from past clearing, leading to reduced connectivity, smaller remnant sizes and greater edge effects impact on the viability of forest ecosystem function. Despite this, there are currently no restrictions on the management of remnant and regrowth forest on private land with the exception of clearing. There are significant issues to be addressed on all tenures in terms of management for maintenance of ecosystem integrity. Threats include vegetation thickening, invasion of weed and feral animal species, fire management and risk of catastrophic wildfire, and subsequent decline in ecosystem functions. Long-term fire ecology experiments are being maintained by DPI&F (House 1995), which investigate the role of fire and species diversity. However, there is little work being undertaken to investigate maintenance of ecosystem integrity.

2.1.2 Health and Condition of Vegetation Remnants on Rural Lands

A multiplicity of factors is known to contribute to rural tree dieback. These include 'natural' agents such as insects, fungi, and climate extremes, and management-related factors such as clearing, use of agricultural chemicals and damage by livestock. Usually a combination of factors is involved, these varying with locality. The main conclusion from a 1980s study of tree dieback across 70 Shires in Queensland was that the extent of tree clearing since first settlement, and the inadequacy of tree replacement, may have contributed most to the problems of tree decline and degradation of rural lands (Wylie *et al.* 1993a). Detailed studies in the Mary River catchment demonstrated a linkage between the extent of tree clearing/ land use in different parts of the catchment, levels of stream water salinity, and the severity of insect-related dieback of trees along streams. Generally, stream water quality was poorest and tree dieback most severe in areas which had been the most extensively cleared/ intensively managed (Wylie *et al.* 1993b) for agricultural production.

It is likely that the same set of factors is still in operation in the Burnett and Mary catchments although the relative importance of individual factors may have changed in the intervening 20 years. While the rate of clearing of natural vegetation in the region has slowed, there nevertheless has been an ongoing net loss of tree cover, a factor shown to be pivotal for the health of the remaining vegetation and environmental degradation.

2.1.3 Over Harvesting and Non – Sustainable Forest Management Practice

Harvest levels from state owned land have reduced over the last decade, particularly in response to the SEQ Forest Agreement. The area of state forest lost to production has largely been absorbed by increased harvesting on private land. In many cases uncertainty over the Vegetation Management legislation has also contributed to increased harvesting rates. In addition drought places pressure on the resource through harvesting timber to supplement cash flows of many landowners reliant on farm incomes. In terms of productive capacity, this reduces future growth as many trees are harvested prior to maximising their value (Ryan and Taylor 2002).

Non-sustainable forest management practice is widespread in the region, resulting from a poor understanding of forest management principles and 'High Grading' (the practice of harvesting all merchantable stems to a minimum size class, rather than leaving some for future productivity gains). Poor forest management practice leads to serious loss of productivity, change in species composition and poor harvesting management resulting in soil erosion, compaction and stream silting (Taylor and Annandale 2000, Taylor 2003).

Future forest productivity relies on appropriate management of regeneration, fire, grazing and species silviculture (Henry 1960, Henry and Florence 1966, Lindenmayer 1999). Two conditions are commonly associated with private native forests :(1) vegetation thickening due to excessive regeneration and severe competition between adjacent saplings and (2) failure of regeneration with a physiologically 'old' forest structure. The former usually results from lack of fire, grazing and general management input and the latter too much fire and grazing pressure. Either condition is detrimental to productivity, ecological processes, diversity and habitat. (Ross 1998).

2.1.4 Overview of Grazing Land Threats

The major threats to the attainment of sustainable grazing practices include:

- Economic constraints; cost price squeeze of production. Economic pressures are a key causal problem in grazing land because they generally lead to:
  - high grazing pressure;
  - more intensive use of less productive and more fragile land; and
  - inability to manage woodland thickening and weed encroachment.
- Impact of grazing management on land condition and subsequent impacts on water quality and land productivity.
- Climate variability and possibly climate change. Significant degradation events in grazing lands are generally linked to major droughts.
- Weeds reduce carrying capacity of grazing land and impact on biodiversity. Weed management is expensive and less successful in lower value and less productive land.
- Upward pressure on land price due to industry cycles, alternative industries and land use (rural residential development) can provide both threats and opportunities. The opportunities for diversification, however, reduce away from the coast.
- There is a broad perception in the industry that introduction of restrictive resource use legislation (e.g. Vegetation Management Act) can be threatening to traditional management practices. Commentators suggest that there are possibly indirect impacts of vegetation management legislation on productivity and management practices as a result of the confusion created by change, and a reduction in confidence in the sector.
- There is a risk that Research and Development (R&D) doesn't adequately address capacity building of stakeholders to enable them to change and that extension services will struggle to deliver effectively if these critical services are not maintained.

2.1.5 Threats to Riparian Zone

Inappropriate grazing management within riparian zones has been linked to a number of on-farm and catchment wide impacts. The key threatening practices include:

- clearing of native vegetation (trees) in riparian zones.
- Unrestricted cattle grazing or access by cattle in riparian lands which can result in:
  - overgrazing
  - trampling of vegetation

- breakdown of soil structure
- riparian bank/channel erosion
- contamination of water with nutrient rich urine and faeces
- increased water turbidity
- removal of riparian trees (can result in in-stream weed and algae growth)
- impacts on species diversity through selective grazing.

Impacts are greatest in either very wet conditions, when susceptibility to bank erosion is greatest, or very dry conditions, when the habitat or refuge value of riparian and in-stream environments to wildlife and aquatic organisms is greatest. In times of drought, ground cover is often reduced to a minimum leading to large exports of sediment with drought breaking storms.

CSIRO sediment and nutrient modelling for the Mary catchment suggests that 87% of the total predicted supply of sediment to channels is from the erosion of riverbanks. This model is considered to be more reliable than those that preceded it with prediction falling within a 20% range of actual sediment loads (DeRose *et al.* 2002). The variation has been attributed to the absence of landslip and channel scouring estimates in the model and potentially a higher sediment delivery ratio from hillslopes than was applied in the model. The availability of good quality land use mapping, digital terrain models and interpreted land resource assessments in the catchment were shown to enhance the accuracy and predictive potential of the model compared to its use at a regional level in the National Land and Water Audit.

2.1.6 Overview of Horticultural Threats

Many horticultural crops require relatively high inputs of water, nutrients and weed and pest management interventions. Without strong environmental management systems or the adoption of best management practice, excessive or poorly applied inputs can lead to a range of downstream impacts. The key areas where poor performance can lead to unsustainable outcomes are:

- quality of water supplied and leaving farms (salinity, sediment, nutrient, chemical and pesticide pollution);
- pesticides and chemicals entering the environment;
- efficient use of limited water resource;
- waste management;
- reduction in soil health (including salinity, erosion, soil acidification etc);
- pests, disease and weeds that lower plant health;
- cropping on unsuitable land for cultivation e.g. steep slopes (more in Mary than in Burnett);
- poor farm design (based on logistics, infrastructure and maximising ground cultivated rather than being dictated solely by topography, soil type etc.);
- poor or no ground cover (particularly in vegetable crops);
- massive cultivation rates for block and bed preparation;
- monoculture driven by market price and demand and grower attitude, personality and preferences.

2.1.7 Threats to the Great Barrier Reef

The natural state of reef ecosystems are adapted to a naturally low nutrient status and increased nutrient levels can damage Reef communities. The nitrogen concentration in run-off

to the Reef lagoon is estimated to have increased three-fold in the last 150 years, while phosphate concentration is estimated to have increased ten-fold (pers comm. CRC Reef Research Centre 2001). It is estimated that 49,000 tonnes of nitrogen and 9,000 tonnes of phosphate are deposited in the Reef lagoon annually. Nutrients lost from cropping activities, appear to be one of the major issues for Reef catchments. The main problem arises from nitrogen and phosphorous exports as a result of both organic and non-organic fertilisers making their way into waterways. Grazing land contributes the largest total volume of sediment to the reef lagoon.

It is estimated that sugar cane cultivation in reef catchments contributes on average about 20,000 tonnes of nitrates per year to the reef (Haynes and Morris 2003, Haynes *et a.l* 2000). Cane lands tend to be at the lower end of catchments meaning there is less chance that contaminants in run-off have time to be filtered through natural systems or deposited in downstream impoundments. This proximity factor increases their relative contribution to nutrient and sediment export to the coast. The Burnett Mary region constitutes about 13% of the reef catchment area and represents 8% of the volume of water discharged to the reef lagoon, it also contributes an estimated 9% of sediment exported to the coast. Table 2.1 Summarises the potential risks and export rates for the various catchments in the region.

Table 2.1. Risk to reef and sediment export rates in the region.

Basin	RWQPP Biophysical Risk	RWQPP Development Pressure Risk	RWQPP Marine Industries Risk	RWQPP Sum of Risks	Catchment area km2 (Furnas 2003)	Mean annual freshwater discharge volume km3 (Furnas 2003)	Sediment exported to the coast (t/y) (NLWRA)
Baffle	2.0	2.0	1.0	5.0	3,996	0.78	103,376.3
Kolan	1.0	2.0	1.0	4.0	2,901	0.41	61,588.6
Burnett / Bundaberg Irrigation Area / Boyne / Three Moon Creek / Barker / Barambah	2.5	2.0	2.5	7.0	33,248	1.15	728,607.2
Burrum / Elliot / Gregory / Isis	2.0	3.0	1.0	6.0	3,358	0.55	33,624.4
Mary	2.5	3.0	2.5	8.0	9,440	2.72	266,713.1

Note: The rankings used in the Reef Water Quality Protection Plan (RWQPP) above are Low –1, Medium – 2 and High – 3.

Hunter and Armour (2001) have shown that nutrient losses at (cane) farm scale are not agronomically important, with an average of 3.5 kg N/ha/year and 0.4kg P/ha/year. Elevated levels of Atrazine and Diuron in irrigation (tailwater) and rainfall runoff have been recorded in sugar research. While there was no evidence of long-term buildup on soil surface or soil profile (potential exception- Diuron), Simpson and Ham (2001) identified the following risk factors:

- dry conditions increased persistence (fastest under wet/hot conditions);
- most of the dissipation is due to breakdown of pesticides (rather than runoff or leaching);
- mobility is highest immediately after application (Atrazine and Diuron levels in storm runoff significantly exceeding ANZECC Guideline values in their research plots.**2.1.8**

Acid Sulfate Soils

Significant acid drainage and soil acidification is still occurring in the lower Burnett, Kolan and Elliot catchments. These soils are manageable although they have been over-drained in the past. Exposing acid sulfate soils can lead to catastrophic downstream impacts including

heavy metal liberalisation leading to fish deaths. Acidification of soils reduces their buffering capacity and research in coastal northern New South Wales suggests that pesticide movement into waterways is greatly accelerated where potential acid sulfate soil landscapes are not managed properly in production systems (Rayment NR&M, pers. comm. 2004).

2.1.9 Siting of Intensive Livestock Systems

If intensive livestock production facilities are not carefully sited, designed, constructed and managed, they have the potential to contaminate surface and underground water resources and to impact adversely on community amenity by the emission of odour, dust and noise. Aesthetic values may also be degraded if facilities are not adequately planned.

2.1.10 Smaller Pre Environmental Protection Act Piggeries

Based on DPI&F regulatory experience, the following environmental management areas are commonly deficient at small 'deemed approved' piggeries (i.e. those with less than 5000 SPU capacity existing at the time of introduction of *EP Act*.):

- Effluent treatment and holding ponds may be undersized or storing large quantities of sludge, severely limiting treatment and holding capacity.
- Effluent storage ponds may be undersized and therefore unable to store excess effluent during extreme or extended wet periods.
- Effluent irrigation equipment may not be capable of applying effluent at appropriate rates over sufficient area of crop or pasture, potentially resulting in nutrient overloading of the soils in the effluent irrigation area.
- There may be insufficient arable land available on the piggery property to enable sustainable use of piggery effluent.
- Effluent irrigation may not be managed with sufficient care to avoid pond overflows or water logging, deep drainage, runoff or nutrient overloading in the effluent irrigation area.
- Effluent irrigation areas may be grazed by beef cattle, effectively removing only very small amounts of nutrients, resulting in nutrient overloading of the soils.
- The base and batters of effluent ponds may not be adequately sealed, resulting in seepage of contaminants through permeable soil or rock into groundwater.

2.1.11 Intensification of Dairying and Grazing

Deregulation has increased economic pressure on dairy farms and has driven more intense land use practices, including supplementary feeding of dairy cattle (See Appendix III). Similar practices in the beef industry have increased as producers introduce 'finishing' regimes, frequently to satisfy meat specifications for export markets. These operations are not generally considered to fall within the feedlot definition under legislation and therefore few documented records of current impacts exist. Intensification, if not managed appropriately, may lead to poor performance with respect to:

- riparian zone management;
- water use efficiency;
- maintaining soil structure;
- nutrient management.

2.1.12 Dairy Effluent and Fertiliser Management

While effluent management practices have been improving in the dairy industry, there are still significant numbers of dairy farms where effluent management is below industry best management practice standards. In some cases, this has resulted from industry deregulation and subsequent herd expansion and intensification, without sufficient consideration being given to the adequacy of existing effluent systems. In these circumstances threats similar to those identified for piggeries above exist. Dairy farms are also high fertiliser users. Fertiliser application should be carefully managed to avoid export of nutrients to surface and underground water resources.

2.1.13 Cumulative Impacts on Coastal Ecosystems

The effects of flooding and cyclones on the seagrass and dugong populations in Hervey Bay in 1992 are though to be significantly increased as a result of poor catchment management. The cumulative impacts of over-grazing, erosion and streambank failures in the Mary catchment may have contributed to the loss of 24% of the known seagrass areas on the Queensland coast and the deaths of at least 99 dugongs (Preen 1995). Around the same time DPI&F was evaluating it's soil conservation program. Smith (1994) identified that the lack of adoption of conservation farming in the Inland Burnett, despite a comprehensive and diverse extension program since the 1980s. Clearly, the ineffectiveness of natural resource management in the past has been a major contributor to cumulative impacts, and this is addressed in detail in Section 4.0.

2.2 TERRESTRIAL WEEDS AND PESTS

The pressure and risks associated with terrestrial weed invasion of productive landscapes and escape from productive landscapes to natural systems are considered so significant that this threat is dealt with as a specific topic throughout the paper. The key risks to sustainable production are associated with the high priority species in the region (section 1.3). In addition to production costs, the main resource management threat from terrestrial weeds is their impact on natural systems including loss of biodiversity in the region. In addition, some production systems increase woodland thickening to create 'weed like' habitats of native species. The relative magnitude of the threat posed by these weeds, and their significance to sustainable production systems, are ranked in Table 2.2.

Table 2.2. Relative impact of terrestrial weeds on sustainable primary production assets (including water quality).

Magnitude of Threat to SPP Assets (incl WQ)				
Large			Cats claw vine (BRC and MRC) Fireweed (MRC and CB)	Giant rats tail grass (MRC and BRC)
Moderate	Rubber vine (IB) Prickly acacia (IB)	Groundsel (MRC and CB) Mother of millions (MRC and BRC)	Parthenium (IB and M/MC) Annual ragweed (MRC and CB)	Lantana (MRC and BRC)
Small	African lovegrass (IB)			
	Low - Moderate	Moderate	High	Critical

RC = Mary River catchment; BRC = Burnett River catchment; CB = Coastal Burnett; IB = Inland Burnett; M/MC = Middle Mary Catch.

2.2.1 Pest Animal Impacts

The major pest animals impacting on primary production in the region include widely distributed pigs, wild dogs and feral cats, and more restricted distributions of wild horses (mainly coastal), deer and rabbits. NR&M have trialled a database in their Maryborough office which records the incidents of attacks on stock and domestic pets, which is the primary threat from wild dogs. Threats from other species are mainly on natural ecosystems although they do have impacts on production e.g. wild pigs (land and wetland degradation), wild horses (pasture competition), deer (seedling browsing in forest plantations), rabbits (pasture competition and burrowing hazards), cats (disease spread and ecosystem service disruption through predation).

2.3 LANDSCAPE SYSTEMS AND APPROACHES

Many of the pressures impact on numerous primary industries, to varying degrees. When developing responses to address risks outlined above, the threats should be addressed in a whole of ecosystem landscape based approach and within a farming systems context. It is important to acknowledge and understand the relationships between particular management actions if poorly applied to natural hazards and consequences in a broader landscape context and these are identified in Appendix V.

3.0 CURRENT RESPONSE BY AGENCIES AND INDUSTRY

3.1 LEGISLATIVE RESPONSES

3.1.1 Legislation

There are a number of state Acts regulating forestry and agricultural activities on state and private land. These include:

- *Nature Conservation Act* (1992)
- *The Forestry Act* (1959)
- *Vegetation Management Act* (1999)
- *Land Protection Act (2002)* – control the declaration and control of weeds and pests and the development of State Land and Local Government Pest Management Plans.
- *Queensland Weed Hygiene Declarations* (2003)
- *Land Act (*including draft Rural Leasehold Strategy)
- *Environment Protection Act* (1994) provides for accrediting of Codes of Practice e.g. Agricultural Code of Practice
- *Water Act (2000),* includes a requirement for the development of a Land and Water Management Plan for enterprises seeking to use 'new' water allocations.
- *Soil Conservation Act (1986)* provides regulatory controls in declared areas and enables group of farmers to undertake coordinated soil conservation planning.
- *Integrated Planning Act (1997)* assesses development permits for defined intensive livestock developments and certain other high-risk agricultural activities.

3.1.2 Codes of Practice

There are number of Codes of Practice accredited under legislation including:

- Code of Practice for Native Forest Timber Production (State Lands) (EPA, 2002). Currently, a code is being developed for private forestry although this is not yet mandatory.
- Farmcare – Code of Practice for Sustainable Fruit and Vegetable Production (QFVG 1998).
- Code of Practice – Sustainable Cane Growing In Queensland.
- Queensland Dairy Farming Environmental Code of Practice (Anon 2001).
- Environmental Code of Practice for Queensland Piggeries (Streeten and McGahan, 2000).

3.1.3 Statutory Agreements

The SEQ Forests Agreement has driven a plantation establishment program, initiating long term forest monitoring and forestry management extension currently provided by Private Forestry South Queensland (PFSQ);

3.2 VOLUNTARY RESPONSES

3.2.1 Improved Management of Private Commercial Forestry

An NHT funded research, development and extension (RD&E) program was conducted by DPI&F for the Mary and South Burnett catchments, addressing improved management of native forests for timber production. Several demonstration forest management areas were established. Permanent monitoring sites were also established and are being documented in a case study currently being compiled for publication. This project initiated a change in forest management as the outcomes demonstrated tangible benefits to production and returns as well as improved environmental protection outcomes.

3.2.2 Grazing Land

Ongoing research into sustainable production systems funded by industry and government has produced the:

- Grazing Land Management education package – property planning;
- Climatic risk management workshops;
- Drought planning workshops;
- Pasture monitoring systems (current and developing);
- Balancing Conservation and Production, best practice guidelines CSIRO Consortium;
- Programs highlighting the benefits of dung beetles; and
- The Australian Land Management System (ALMS) (Synapse Research and Consulting 2004). has been developed as an Environmental Management System (EMS) that incorporates catchment and biodiversity priorities into on-farm natural resource management.

3.2.3. Water Quality

A series of Statewide joint-venture projects are being implemented to address several NRM issues (AgSIP projects). These will address self-management practices, education and extension, research and information sharing. Specifically AGSip Project 05 will identify water quality on a systems approach and AgSIP 16 project will identify water quality on an individual farm approach within the dry tropics.

In areas where there is an identified 'current' issue, NR&M is working collaboratively with growers in that area to monitor, regulate, and prevent/reverse the issue. A moratorium on groundwater development in the Farnsfield area was recently put in place (a high-risk area of intense groundwater use).

3.2.4 Industry Response to Pesticide Reduction and Integrated Pest Management

There are a number of tools and protocols being developed including:

- Pathways to EMS (DAFFA 2004) is an initiative being managed by Horticulture Australia started in 2004 and aims to develop an Environmental Assurance protocol (best practice);
- QFVG Farm Management Systems toolkit for horticulturists in Queensland to build on to the Farmcare Code of Practice (1998);
- Enviroveg self-assessment protocol for the Australian vegetable industry (Ulloa 2002). EnviroVeg is an environmental program developed for vegetable growers across Australia to use on their farms to demonstrate and improve their environmental management practices.
- DrumMUSTER focuses on sound practices and appropriate drum disposal options and covers all industries.

There are a range of innovative integrated pest management (IPM) strategies being adopted in horticulture including :

- use of IPM strategies by an estimated 90 percent of macadamia plantations in Queensland, using monitoring by pest scouts and MACMAN (Mulo 1999), a powerful recording and reporting system for monitoring and improving macadamia nut quality and orchard management has been widely adopted by the industry
- adoption of IPM strategies by the strawberry industry in Queensland, including the pest-in-first mite program, strategic spraying for heliothis, and the phase out of methyl bromide by 40 percent of growers

- participation by virtually 100 percent of the citrus industry in IPM strategies, estimated to have saved $7 million per year in Queensland (Smith 2001) when compared with the spray schedules used in the 1960s; and
- the use of targeted insecticide application (bell injection) in the banana industry leading to an estimated 85 percent decrease in total insecticide applied to fruit (Campagnolo and Lindsay 1999).
- Canegrowers have introduced the GrubPlan program of IPM that addresses industry specific issues (Sugar Research and Development Corporation (a) current).

3.2.5 Efficient Use of Water

Dairy (including lucerne growers), Canegrowers and QFVG successfully completed Phase 1 of the Rural Water Use Efficiency program for their industries and are actively rolling out Phase 2, which has an expanded focus. 'Water For Profit' (QFVG) and Canegrowers project officers are active in the region. The sugar and horticultural industries have been actively engaged with NR&M in the region developing mapping products and workbooks to facilitate the development of Land and Water Management Plans (Water Act 2000) in the key Burnett and Mary River growing areas Canegrowers and Bundaberg Sugar maintain the GIS system containing good quality resource information and conduct the workshops using the workbook developed in conjunction with NR&M.

3.2.6 Nutrient Management

Nutrient management is a part of several DPI&F, CSIRO and industry partnership research, development and extension (RD&E) programs with grain and cropping industries. Activities include on-farm and field research combined with participatory extension projects to supplement and support laboratory-based studies. It has been found that this approach is received positively by producers, which facilitates voluntary uptake (Lawrence *et al* 2002).

Other nutrient management initiatives include:

- The BSES Limited endorses use of soil tests and provides a leaf sample testing service for growers. They run education and extension on the benefits of matching fertiliser applications with soil requirements within the Bundaberg Sugar soil testing system.
- The COMPASS program was developed by the sugar cane industry in 2001 to provide cane growers with a practical self-assessment tool using a workbook and workshops (Azzopardi 2001). COMPASS covers nutrition and fertiliser use and riparian management. To date over 1000 growers have undertaken the program. 20% of CANEGROWERS members within the Southern cane growing region have undertaken the program.
- Research conducted by the CRC for Sugar on better fertiliser management included recommendations departing from standard application rates and making better use of re-cycled nutrients. Key information developed by the CRC was packaged into the Sustainable Nutrient Management Short Course manuals and is now the basis of training programs for growers.
- The FERTCARE program has been developed by FIFA. It is a self-regulation, accreditation and code of practice program for fertiliser sales and application professionals and agronomy advisers.
- Development of nutrient management guidelines for the cane growing region.
- Accelerated adoption of best practice nutrient management (SRDCb). This includes the development of a soil capability and management package for improved on-farm decision making re nutrient management.

- Grain in Cane project – break cropping for farm diversification and soil health benefits.

3.2.7 Chemical Management Tools

To avoid water contamination with nutrients and pesticides, the Sugar Yield Joint Venture program recommended that the problem needs to be tackled at source. This means avoiding excessive nitrogen application rates; apply nitrogen in dry season; time applications to match crop demand; protect from surface wash-off. Further recommendations included the use of oil cover; retention of vegetative buffers; alternative irrigation methods and minimising tail-water delivery to streams (through re-cycling dams, constructed wetlands and effective riparian buffer zones to trap sediment and nutrients to reduce sub-surface nitrate).
CANEGROWERS have introduced a range of tools and protocols to improve chemical management including:

- ChemCert data (ChemCert Australia);
- SafeGauge – decision tool which integrates soil type, crop presentation, irrigation methodology, rainfall probability and pesticide profiles to provide grower, extension officer, adviser with information about the off-farm risk of a proposed application. Produced by NR&M in consultation with the industry.
- DrumMUSTER focuses on sound practices and appropriate drum disposal options and covers all industries

3.2.8 Eco-Efficiency Agreement

CANEGROWERS have signed an eco-efficiency agreement with the Federal Minister for Environment and Heritage. The agreement commits the organisation to trialling public environmental reporting and promoting the more efficient use of environmental resources through COMPASS. CANEGROWERS proposes to develop agreed regional canegrowing eco-efficiency indicators, which will then assist the regional industry to report on its progress. QFF have entered into a similar agreement.

3.2.9 Farm Management System Framework

As part of the RWUEI 2 program, the fruit and vegetable and cane growing industry bodies have committed to developing a farm management system framework that integrates efforts aimed at assisting growers adopt and implement best practices. This will assist in streamlining delivery of training, information provision and allocation of resources. Consultation on *FMS Standard for Sugarcane* (SRDC 2005) is now underway. An intensive agriculture approach is being developed with QFF to gain recognition from state government and regional NRM groups. Further funding has been received from Department of Agriculture, Fisheries and Forestry (DAFF) through the *Pathways* program to assist the industry in the implementation of the FMS Framework. SRDC and CANEGROWERS are the key proponents of this project.

3.2.8 Erosion and Soil Health Management Systems

While there are no silver bullets, DPI&F, NR&M, BSES and CSIRO have undertaken substantial research to develop farming systems that are sustainable. The work of Bell and Bridge (2001) and Bell *et al.* (2001c) and the experience of innovative farmers has revealed several management practices that can ameliorate the effects of compaction in cropped Red Ferrosols. These include the use of periodic ley phases, deep ripping, and opportunity cropping with zero till /controlled traffic. Similarly, the Sugar Yield Decline Joint Venture has done significant work on soil health, improved farming systems and has made excellent advances in the adoption of better farming practices. Garside *et al.* (in press) and Bell *et al.* (2003b) have developed a sugar cane cropping system involving controlled traffic, minimum

tillage, trash blanketing and legume or bare fallow regimes which improve profitability, sustainability and environmental responsibility. Breaking the sugar cane monoculture for even short periods (6-9 months) with alternate crops and bare fallows has been shown to increase cane yields while producing a more balanced soil biology. Continued focus on a 'farming systems' approach is essential to achieve sustainable production goals.

The adoption of minimum tillage practices in cereal cropping areas has shown a general upward trend over the last twenty years due to the reduction in cost of suitable herbicides which reduce the need for tillage to control weed growth. Leaving stubble intact and stubble mulching are now considered best practice. Regional uptake is summarised in Table 3.1. Green cane trash blanketing has also recorded similar levels of uptake in the region (pers. comm. G. Kingston, BSES, Bundaberg 2004).

Table 3.1. Stubble management in the Wide Bay- Burnett region (2001)

Statistical Division	Stubble left intact (ha)	Stubble removed by baling, grazing (ha)	Stubble removed by burning (ha)	Stubble ploughed in (ha)	Stubble mulched (ha)	Other methods (ha)	Total	Good practice %s
Wide Bay-Burnett	7,790	6,841	1,557	31,359	4,912	1,558	54,017	2.89%

Source: Responses from a question relating to stubble management in the Queensland Agricultural Census 2001

3.2.9 Response to Land Degradation, Salinity and Landcare

A nationwide survey of broad acre and dairy farmers provides some ball park indications of Landcare related responses in these industries in the region (Nelson *et al.* 2004). In Queensland around 28% of enterprises had representatives involved in Landcare Groups. In the Burnett Mary between 40-60% of enterprises were involved in production-based groups with a natural resource management component while less than 20% of growers had accessed NHT or NAP funding. Throughout Australia 93% of all broad acre and dairy farmers who reported significant degradation problems had changed farm management practice or were intending to do so in the following year.

All major stakeholders in sustainable production including CANEGROWERS, QFVG (now Growcorp) QDO, AgForce, DPI&F and NR&M are continually promoting more sustainable farming practices such as reduced tillage, controlled traffic, rotational crops, nutrient management, chemical accreditation, land and water management planning and self-assessment of sustainability. One example is the Isis Sugar Industry, which has established its "Isis Target 100", a proactive, industry-driven productivity initiative designed to encourage more sustainable farming practices. It promotes the benefits of break cropping with legume crops that improve soil health. Based on current predictions, the area of land under break crops in the Isis mill area is likely to increase 10 fold this season due to the success of the Isis Target 100 initiative.

Agroforestry has a vital role to play in reducing salinity caused by rising water tables. Claridge *et al*. (2001) have demonstrated that strategic placement of tree plantations on agricultural land can significantly reduce this problem. One indicator of the extent of native hardwood plantation uptake comes from the Queensland Government Joint Venture Project set up subsequent to the SEQ Regional Forest Agreement. Approximately 5,200 ha of plantation has been established with the majority of this involving some form of agreement with private landholders and the government, the balance through purchase of land by the government.

3.2.10 Feedlotting

Since 1996, State regulation and industry self regulation, in conjunction with the industry's genuine commitment to improving its public image and achieving long term sustainable growth, have contributed to significant advances in feedlot environmental management over the past two decades. These have resulted in a high level of adoption of best management practices and an awareness of environmental issues within the industry. Key voluntary initiatives leading to improved performance include:

- the industry initiated National Feedlot Accreditation Scheme (NFAS);
- Queensland Government Guidelines for the Establishment and Operation of Cattle Feedlots (DPI, 1989),
- National Guidelines for Beef Cattle Feedlots in Australia (ARMCANZ, 1997),
- National Beef Cattle Feedlot Environmental Code of Practice (MLA 2000)
- Reference Manual for the Establishment and Operation of Beef Cattle Feedlots in Queensland (Skerman, 2000); and this has also provided readily accessible guidance on implementing and upgrading a wide range of environmental management practices.

3.2.11 Piggeries Current Response to NRM

Australian Pork Limited (APL 2003) has recognised the need to improve the industry's image and to educate producers regarding environmental management issues, as outlined in it's Draft National Environmental Strategy for the Pig Industry (APL, 2002). To address this need, APL has funded the development of national environmental training packages that have been presented to producer groups in centres within the Burnett catchment over recent years.

3.2.12 Dairies

In recent years, the dairy industry, through Sub-tropical Dairy, Dairy Australia and the Queensland Dairy Farmers Organisation (QDO) has developed and implemented a number of programs to assist producers in addressing NRM issues. These programs include:

- Dairying Better 'n Better – focusing on better irrigation, soil, fertiliser and effluent management for improved production and environmental outcomes (Anon 2002).
- Dairy SAT (self assessment tool) – to assist producers in identifying any deficiencies in their NRM management (Nielson and Olivia 2003).
- Several other production-focused projects consider the environmental implications of production systems (M5 Farmlets project and the Warm Seasons Legume project).

The Mary River Catchment Coordinating Committee in conjunction with the QDO have administrated grants programs to assist producers with effluent management and riverbank restoration. DPI&F also provides a dairy effluent extension service to assist producers with the planning and design of new and upgraded effluent management systems.

3.2.13 Terrestrial Weeds

There are a range of strategies which guide management actions and policies (outlined in more detail in Appendix IV) including:

- The National Weed Strategy (NWS) 1999.
- Queensland Weeds Strategy 2002-2006.
- Weedy Sporobolus Grasses Strategy 2001.
- Queensland Parthenium Weed Strategy 1999-2004.

- Queensland Policy for the Development and Use of Leucaena (2003).

There are also four Queensland Best Practice Weed Management Manuals:

- Giant rats tail grass best practice manual (1999).
- Parthenium weed best management practice (1999).
- Rubber vine management – control methods and case studies (2004).
- Creeping Lantana Handbook (2001).

A series of published NR&M Fact sheets outline useful information relevant to the ecology and management of the priority weeds for this region.

3.2.14 Reef Water Quality Protection Plan -APS

The Reef Water Quality Protection Plan is a comprehensive whole-of –government strategy aiming to arrest the decline in water quality flowing from catchments to the reef. There are numerous strategies that target actions toward increasing the sustainability of agricultural production. In particular, the plan promotes the development of the "*Agricultural Performance System*" (APS) currently under development by DPI&F, which aims to address priority risks such as erosion, nutrients, pesticides and riparian zones. While only at working draft status it is understood the system will strongly promote voluntary adoption of better practices and property management planning approaches.

3.2.15 DPI&F Research, Development and Extension

The Department of Primary Industries and Fisheries is the largest provider of research, development and extension on sustainable production, with a current annual budget for natural resource management projects in the Burnett Mary Region of around $4 million. Table 3.2 summarises the main aspects of the portfolio which are outlined further in Appendix VI.

3.2.16 Broad Incentive Programs

There are a range of incentives available for farmers to achieve more sustainable production systems including:

- *NHT/ ICM type grants* – For the past decade or more grants have been available for Landcare type works on farms.
- *QRAA*: Concessional loans are available through the Queensland Rural Adjustment Authority for certain Landcare type works undertaken on properties. This includes the construction of soil conservation works, erection of fencing, the modification of tillage and harvesting machinery and the reclamation of degraded land.

Table 3.2. DPI&F Current capabilities: NRM in Sustainable Production Systems

RESOURCE CONDITION and MANAGEMENT	SUSTAINABILITY in FARMING SYSTEMS
Assessment of vegetation ecology	Determining economics of grazing management strategies
Determining economics of grazing management strategies	Development of environmental codes of practice
Development and application of sustainability indicators	Development of sustainable waste management practices
Development of land condition monitoring tools	Development of tree-based systems to manage water on-site
Development of sustainable grazing management systems	Efficient water use
Forest health surveillance and monitoring	Integrated pest management
Management of grazed woodlands	Reducing pesticides in the environment
Minimising erosion and sedimentation	Seasonal forecasting of yield
Monitoring and interpreting changes in land condition	**CAPACITY BUILDING**
Services and tools to rehabilitate degraded lands	Targeted training
Soil health management	Integration of skills and disciplines
Controlling horizontal and vertical nutrient flows	Landholder capability building

- *EMS:* The Australian Government will provide support to primary producers who develop and implement an environmental management system (EMS). The EMS Incentives Program provides cash reimbursement for activities associated with the development and implementation of an EMS.
- *Farmbis:* Farmbis subsidises training for the development of business or property plans and the undertaking of training towards better management of natural resources.
- *Landcare - Taxation:* Landcare operations cover what were previously known as land degradation measures. Landholders can claim a deduction in the year they incur capital expenditure on a Landcare operation for land in Australia. A Landcare operation is one of the following:
    - eradicating or exterminating animal pests from the land;
    - eradicating, exterminating or destroying plant growth detrimental to the land;
    - preventing or combating land degradation other than by the use of fences;
    - erecting fences to keep out animals from areas affected by land degradation to prevent or limit further damage and assist in reclaiming the areas;
    - erecting fences to separate different land classes in accordance with an approved land management plan ;
    - constructing a levee or similar improvement; or
    - constructing drainage works - other than the draining of swamps or low-lying areas - to control salinity or assist in drainage control.

4:0 OVERVIEW OF THE LIMITATIONS AND CONSTRAINTS TO RESPONSES

4.1 WHY THINKING LIKE A STEWARD IS NOT ENOUGH

By the late 1980s and early 1990s studies indicated that Australian producers held a strong stewardship ethos (see Curtis and De Lacy 1997, Vanclay and Lawrence 1995). However, rarely does the attitude of stewardship translate into behaviours of improving natural resource management practices on private land. Whilst there is some acceptance of the environmental problem among primary producers, a number of external constraints may also impede the uptake of conservation-oriented practices. Farmers' positive attitudes to landscape integrity do not automatically predispose them to adopting recognised conservation techniques (Vanclay and Lawrence 1995). In terms of sustainable resource management, a positive attitude to the environment might be a necessity, but is hardly a sufficient factor to drive the adoption of environmentally-sound practices. Lawrence *et al.* (2002) have identified four main reasons explaining why producers professing stewardship continue to practice poor natural resource management. They consider that uptake will not occur when:

- there is no knowledge of the problem;
- the problem is contested;
- the problem is denied;
- the problem is accepted but:
  - it is rational for farmers to continue with the present system of production
  - farmers have few ideas about how to alter current practice or move to alternatives
  - financial circumstances dictate 'business as usual'
  - the nature of agriculture militates against change
  - governments are blamed for causing the problem
  - it is viewed as 'too far gone'.

A range of limiting factors are discussed under these four broad headings below.

4.2 NO KNOWLEDGE OF THE PROBLEM

4.2.1 Regional Level Issues

The current level of agency and private sector extension capacity and capability is considered insufficient by most to auger in sustainable production on a regional scale. In the majority of cases, lack of knowledge of a problem at a farm level is linked to inadequate transfer of technology and information, rather than a lack scientific understanding of the issue. Comprehensive long-term extension, action learning and action research is required to ensure resource manager knowledge is enhanced in regard to the issues listed throughout this paper.

4.2.2 Forestry

The main gaps in our understanding of forested ecosystems include:

- The health status of remnant and riparian vegetation in the region.
- Environmental impacts of fire and grazing management and fire risk assessment in private forests.
- The impacts of native forest and plantation management on soil and water processes such as water quality and yield effects of native forestry and plantations.
- Knowledge about the strategic location of forestry development at the scale of farm and catchment topography within the landscape.

4.2.3 Grazing

Future research in the areas of pasture development, woodland ecology and management, pasture ecology, grazing systems, fire regimes and conservation needs to focus on:

- finer nuances of grazing systems;
- management impacts on bio-diversity;
- risk management (climate); and
- spatial arrangement of connective strips and clumps of woodlands.

4.2.4 Horticulture

Major gaps in information and knowledge include:

- Knowledge is poor at a local, sub-catchment and farm level regarding the extent of water quality/use and pesticide problems.
- Stream water information and monitoring is inadequate in terms of extent and coverage to identify likely water quality problems and their source, nor is it sufficiently available to inform landholders.
- There is no analysis or statistics for on-farm levels of nutrient/sediment run-off as opposed to catchment level monitoring.
- Knowledge of hydrological and ecosystem functions of the riparian zone in horticulture in terms of nutrient and pesticide movement is lacking.
- There are few cost effective alternatives to soil fumigants and plastic mulch.
- There is a lack of research on minimum till and other soil productivity systems in vegetables.
- There is poor understanding of the costs/benefits of effective water use comparative to other key productivity factors.

4.2.5 Cane and Field Cropping

Further research, development and extension is required to:

- quantify nutrient requirements, losses, crop uptake and subsequent removal, and training in farming practices that enhance nutrient use efficiency;
- enhance extension delivery to inform decision makers and to encourage producers to target the amount of fertiliser required, through understanding soil and crop requirements and identification of risks of nutrient loss. (NLWRA 2001);
- develop more eco-safe pesticides and enhanced uptake of integrated weed management strategies to reduce the downstream impacts of pest control;
- characterise acid sulfate soil in the lower Burnett and Kolan catchments.

4.2.6 Piggeries and Dairies

The uptake of Best Management Practices would increase if simpler methods could be developed to address some of the more difficult issues facing producers such as:

- ensuring that effluent ponds are impermeable;
- effluent pond de-sludging;
- sludge drying and processing and application to land;
- deep litter processing and spreading;
- soil monitoring;

- a program for sustainable effluent and solids application.

4.2.7 Terrestrial Weeds

There is a lack of knowledge of cost effective management mechanisms to prevent weed seed spread. Biological control of invasive weeds remains the most long-term, sustainable option for management but there are gaps in the development of biological agents for the priority weeds in the region. Biological agents are not available for the control of giant rat's tail grass, cat's claw vine, fireweed, annual, ragweed, mother of millions, creeping lantana and rubber vine.

4.3 THE PROBLEM IS CONTESTED

A large national study has found that the amount of change in environmental attitudes between 1991 and 2000 is about the same among Landcare group members and those who are not members (Reeve 2001). Overall, rural environmental issues are now better understood than they were a decade ago. However, there is now less support for policies likely to increase costs in farming, but increased support for policies involving public subsidies for preventative or remedial measures against land degradation. The survey shows that there is very strong support for the view that farmers should be compensated for loss of income or autonomy of decision-making due to measures taken in the public interest. It also identifies that farmers are more likely to contest the need for action, suggesting the problem belongs to the government, not to themselves. Failure to develop change management processes which ensure producers feel ownership both of the problem and its solution will increase the level of constraint to uptake.

4.4 DENIAL OF PROBLEMS

Denial is frequently associated with a lack of appreciation of unseen processes e.g. salinity while still under the ground, and bed incision/ habitat loss below the water in rivers. Another example of denial, comes from respondents in the Burnett Mary region in a nationwide survey of broad acre and dairy farmers (Nelson *et al.* 2004). The results of this survey suggest that not one person reported any significant degradation in terms of dryland salinity, water logging or soil quality, and generally only up to 20% reported significant weed, water quality problems and erosion (up to 40% in some parts of the region) as a form of degradation on their property. Knowledge of the landscapes in the region suggest either the sampling was inadequate or there was considerable under reporting of degradation.

4.5 THE PROBLEM IS ACCEPTED: BUT IS IT RATIONAL TO CONTINUE OR VIABLE TO CHANGE?

4.5.1 Chemical Runoff – 'make sure management'

The Productivity Commission (2003) suggested that practices to abate chemical runoff from farms are not readily adopted because they are seen as being risky or unprofitable, the benefits have not been made clear, or there is a lack of acceptance that chemical runoff is being transported off-farm. Furthermore, climate variability and market uncertainty have resulted in a conservative or cautious approach to farming (Vanclay and Lawrence 1995).
These issues are manifest in farming practices such as:

- 'Make sure' management strategies which may be applicable to chemical use. The application of an amount of an agricultural chemical at the high end of (or above) the recommended rate to avert the deleterious effects of a subsequent episode of heavy

rain or a high infestation of a pest, as 'insurance applications', which provide some psychological benefit at minimum cost (Schroeder *et al.* 1998).

- Constraint to uptake of benign (soft) chemicals due to the potential cost from loss of yield if not applied in combination with crop monitoring and IPM practices which can be more complex and not always based on exact science..

4.5.2 Riparian Management Barriers

Several barriers to the uptake of riparian zone practices have been identified, including:

- fencing is too expensive;
- small property sizes make it unviable to lock up portions of land to prevent stock accessing the riparian zone;
- frequent and/or severe flooding destroys fencing, which represents a significant cost to the landholder;
- weeds may infest areas excluded from grazing;
- poor understanding of the benefits of maintaining healthy riparian areas;
- cost of maintaining infrastructure; and
- disadvantages of off-stream watering points.

4.5.4 Intensive Livestock – Economics

The main impediments to adopting best management practice in feedlotting, piggeries and dairies are primarily related to economic issues including:

- Periodic fluctuations in national and international beef markets, grain prices and climatic conditions over the past 20 years have resulted in 'boom and bust' cycles within the State's feedlot industry. Consequently, it is more difficult for small feedlot operators to justify expenditure on upgrading facilities that only operate intermittently.
- Economy of scale issues may reduce investment in environmental management systems by smaller piggeries.
- The combined effects of deregulation and the accompanying drop in milk prices on top of severe drought conditions and high feed commodity prices have severely affected the profitability of dairy farming. Producers are reluctant to spend any money on aspects of their operation that they do not perceive as bringing an immediate economic return.

5.0 – OPTIONS RECOMMENDED FOR A REGIONAL NRM PLAN

5.1 POLICY PRINCIPLES

5.1.1. Promote 'Natural Capitalism' In Sustainable Production

Develop a 'Natural Capitalism' framework to plan strategically major shifts in the way natural resources are valued and used through the promotion of eco-efficiency principles. Under such a framework farmers will be seen as businesses protecting the environment at a profit. Develop a program to analyse and reduce the ecological footprint of primary industries through techniques such as life cycle assessment.

5.1.2 Recognise Market Failure

Recognise that while eco-efficiency can achieve major advances, market failure impacts significantly on the ability of producers to undertake sustainable primary production viably.

A fundamental underpinning policy, therefore, must be the recognition that some level of regulation and some level of payment for the delivery of ecosystem services is required to achieve long-term sustainable outcomes.

5.1.3 Investigate Market Based Instruments

Investigate Market Based Instruments (MBIs). While serving the same purpose as the options discussed above, they differ in that they aim to set up markets, or establish pricing systems within markets that value the unpriced goods which are generated from good environmental management (e.g. clean water, uncontaminated soil, diverse ecosystems). Investigate possibilities for regional delivery and partnerships with other regions and Local, State and Federal governments.

5.1.4 Participatory Landscape Approaches to Priority Sub-catchments

Promote and adopt landscape/subcatchment scale programs which integrate efforts to promote on-farm adoption of improved practices. Establish voluntary participative and adaptive management groups to satisfy producers' need for site-specific information, and the need to demonstrate 'cause and effect', through 'adaptive management' frameworks, (e.g. Neighbourhood Catchment, Integrated Area Wide Management, productivity 'cell groups' see Appendix VII).

5.1.5 Support Industry Based Programs

Develop partnership programs between industry, Government and the Regional Body to build sustainable production components into existing projects specific to the region (e.g. QFF Farm Management Systems). Identifying preferred delivery mechanisms for different industry groups is likely to lead to increased adoption of NRM.

5.1.6 Farming Systems

Encourage and support the adoption of Farming Systems approaches to problems and their resolution. The basic principles of a farming systems approach to research and extension include the use of multi-disciplinary teams that consider component interactions within a system. It should cover social, economic and environmental aspects of farm and production systems.

5.1.7 Support Environmental Management Systems

Develop a policy that provides privileged access to certain incentives/ ecosystem payments/ grants upon successful accreditation in industry-based environmental management systems. Intensive industries, in particular, benefit from developing EMS to demonstrate compliance.

5.1.8 Use of Predictive Systems Modelling

Invest in the development of Predictive Systems Modelling which can interrogate and run scenarios that help scientists and stakeholders understand the implications of increasing use and pressures on land, water and vegetation resources. The complexity of ecosystems and their response to productive uses demands increased knowledge of system functions to refine management options.

5.1.9 Support Safe Biotechnological Solutions

Support and consider investment in regionally specific biotechnology, research, development and extension. Technologies that may assist the region achieved its desired resource condition targets include:

- biological control of pests and weeds;
- integrated pest and weed management;
- water efficient crops;
- environmentally benign pesticides; and
- more efficient fertilisers.

5.1.10 Terrestrial Weed Policy

Develop strategic weed priorities identified in this Technical Paper focussing on:

- coordinated weed prevention strategies, promoting strategic action to limit the susceptibility to weeds by understanding the pre-conditions for invasion;
- integrated weed management packages which integrate with better land management practices e.g. pasture cover/ground cover;
- increased development of selective herbicides with reduced risks to the environment;
- increased biological control research, development and release for key gaps in existing controls; and
- developing and implementing “best bet” strategies for key regional weed species.

5.1.11 Intensive Livestock Strategies

Devise an Intensive Livestock Action Plan that prioritises policy implementation through voluntary adoption and incentives. Set strategic direction for intensive livestock priorities in the region including addressing the following issues:

- Resolve legal status or regulatory policy for drought feedlots, paddock (grain-assisted) feeding and small feedlots, intensive dairies and deemed approval piggeries.
- Encourage the further development of centralised facilities for the composting of feedlot and piggery solids.
- Support ongoing research to improve methods in the areas of pond de-sludging, sludge drying, handling and processing, deep litter processing and spreading and soil monitoring.

5.1.12 Landholder Capability

Developing packages to build landholder capability in sustainable production systems while providing tools to assist landholders achieve their own and regional goals. Commit to ongoing support for initiatives to service client groups. Engage landholders in research, development and extension and encourage mutually agreed sustainability indicators and targets.

5.1.13 Extension Capacity and Mentoring

Maximise mentoring opportunities for young staff with experienced personnel in industry and government, to ensure intergenerational knowledge transfer. Agricultural extension is a form of co-learning within healthy relationships and should be valued as a specialist skill. The delivery of all sustainable primary production policies should be underpinned with good extension and education.

5.1.14 Community Awareness and Relationships

To gain popular support for investment in sustainable primary production, it is important that the whole community is aware of problems, their causes and the social, economic and environmental aspects of the issue. While extension seeks to facilitate the transfer of knowledge and new technologies, awareness-raising aims to increase the level of understanding of the broader community. Local NRM alliances between producers, consumers and the community can be valuable, as can information campaigns at a regional level. A fundamental understanding of sustainable production issues in urban and regional communities, helps to achieve political support.

5.2 RECOMMENDED IMPLEMENTATION RESPONSES

5.2.1 Establish a Brokerage for Market Based Instruments

Establish a brokerage for regionally focussed Market- Based Instruments (MBIs), such as those investigated in Policy Option 5.1.3, and any state –wide MBIs developed through other initiatives including:

- nutrient and salinity trading schemes;
- an offset scheme between local government, developers and rural producers to achieve nutrient reduction to meet desired water quality objectives more efficiently; and
- Green badging, EMS and accreditation schemes

5.2.2 Establish a Funding Stream for Ecosystem Service Payments

Establish a funding stream for resource managers who generate ecosystem services above that expected by legislation. Implement payment systems which link benefit to action like those successfully adopted in Europe and elsewhere. These include annual payments that reflect the cost of opportunities foregone to enterprises with more sustainable catchment management practices such as riparian management and corridor protection.

5.2.3 Implement Sustainable Production Systems Partnerships

Implement policies on participatory landscape approaches to hot spot sub-catchments (5.1.4), building NRM into industry based programs (5.1.5) and farming systems (5.1.6) to achieve seamless on-ground delivery of sustainable production systems programs. Target action toward policy priorities including those generated from the use of Predictive Systems Modelling (5.1.8) and the Terrestrial Weeds Policy (5.1.10). Maximise uptake of best management practices within sustainable production systems through partnerships.

5.2.4 Expand Rural Water Use Efficiency Projects and Run Off Monitoring

Expand the rural water use efficiency initiative to maximise adoption of efficient water use technology and practices as well as effective re-use of waste streams, to deliver on a range of eco-efficiency principles outlined in the ‘Natural Capitalism’ Policy (5.1.1). Develop producer based monitoring networks through initiatives such as those developed in the Integrated Area Wide Management model. Include storm event monitoring as part of this framework to gain a better appreciation of downstream effects of management practices.

5.2.5 Nutrient Management Program

Invest in projects targeting improved nutrient management, implementing strategies and systems approaches including:

- managing nutrient applications to limit available nutrients, including: soil and plant testing, nutrient 'budgeting' and using crops designed to replace nutrients;
- using appropriate buffering such as filter strips and vegetated riparian zones and plant species designed to target particular nutrient types;
- aligning fertiliser application with irrigation processes (e.g. fertigation) and reusing nutrient rich runoff by using tail-water recycling (irrigation systems);
- recycling nutrients through green cane trash blanketing; and enhancement of dung beetle populations in grazing systems.

5.2.6 Reduce Impacts of Pesticides and Chemicals

Invest in projects to reduce the impacts of chemicals used in pest and weed control including those which aim to:

- reduce the quantity and environmental hazards associated with chemicals used;
- increase the use of biological control agents and 'biopesticides' including allelopathic cover crops and companion crops;
- increase the use of integrated pest and weed management strategies; and
- rehabilitate agricultural landscapes to provide natural checks and balances to pest and weed invasion and filtering services for agricultural chemicals.

5.2.7 Natural Area and Riparian Management Program

Invest in projects that increase the protection and management of natural areas in productive landscapes,focussing on maintaining or enhancing the natural ecosystems services provided by:

- biologically diverse habitats;
- healthy riparian zones;
- functioning wetland systems;
- appropriately located, deep-rooted tree cover;
- connected remnant ecosystems; and
- aesthetically pleasing, culturally significant landscapes.

5.2.8 Implement 'Best Bet' Weed Strategies for Terrestrial Weeds

Implement regional 'Best Bet' Weed Management Strategies as prioritised in Table 5.1 below.

Table 5.1. Implementation risk: A priority ranking of the benefits and implementation responses

Priority Ranking	Weed Strategy Implementation Responses
Priority 1 Very highly recommended	***(very high benefit: low/moderate implementation risk)*** Community awareness/early identification weed campaign e.g. fireweed Implement fence line buffer strips (for GRT grass) Restrict grazing to prevent seed spread (prickly acacia) Scouting for new infestations on clean land Early intervention to control new/isolated infestations Quarantine stock before movement Promote the drumMUSTER recycling scheme Facilitate accredited weed management training for Council and Public Utility field workforces.
Priority 2 Highly recommended	***(very high benefit: high implementation risk)*** 1. Property weed management plans 2. Facilitate a LA receival scheme for unwanted or out of date herbicides 3. Maintain dense competitive pastures/groundcover 4. Engage plant nurseries to prevent sale of weed plants 5. Prevent rubber vine forming dense thickets
Priority 3 Recommended	***(very high benefit: very high implementation risk)*** 1. Adopt the Weed Hygiene Declaration process 2. Adopt a package of best grazing land management practices 3. Eradicate seed plants from upper watercourses
Priority 4 Consider high cost of doing nothing	***(very high benefit: severe implementation risk)*** 1. Facilitate/provide machinery washdown facilities 2. Facilitate increased biological control agents 3. Facilitate the development of more efficient herbicide use strategies

5.2.9. Encourage the Application of Bioremediation and Recycling Technologies

Invest in projects that adopt and promote bioremediation and recycling technologies and practices including:

- using treated effluent to grow trees and recycled water to irrigate open spaces/crops;
- selecting trees for the rehabilitation of saline sites;
- using sewage sludge (biosolids) as a fertiliser on a range of crops;
- use aquatic plants (e.g. constructed wetlands) to reduce effluent loads;

5.2.10 Sustainable Forest Management Package

Collaborate with RD&E providers to:

- Develop an inventory of the type, scale and intensity of native forest management practices.
- Undertake a review of the regional potential for sustainable timber plantations and land rehabilitation under trees with optimal environmental impacts.
- Establish guidelines for private native forest practice applicable to the region.
- Assess water quality and yield impacts relating to harvesting and management practices in native forests and plantations.

- Extend and enhance the fire ecology experimental program, incorporating grazing management, at another strategic location in the Burnett catchment on private land to monitor the effects of different burning regimes.
- Carry out a check of the health of waterways throughout the region assessing factors such as stream and soil salinity, vegetation structure, tree health status, impacts of weed invasion, biodiversity and related land use.
- Review the condition of remnant vegetation and assess the impacts of remnant health and ecosystem function on the productivity of adjacent agricultural landscapes.

5.2.11 Grazing Land Management

Invest in known programs and approaches which achieve results in the grazing industry including:

- further develop and implement the *Grazing Land Management Education Package*;
- develop property and subcatchment scale case studies to demonstrate best practice;
- undertake full economic modelling of recommended changes to management practice; and
- promote the integration of alternative land use systems (e.g. Agroforestry, farm / eco-tourism).

5.2.12 Intensive Livestock Action Plan

Implement an action plan and environmental education programs which enhance NRM outcomes from intensive livestock industries including:

- implementing improved management of effluent and solid application, both on and off site;
- developing and implementing nutrient management plans to account for all nutrient applications and to demonstrate sustainable production practices; and
- implementing good design and construction principles for effluent ponds to limit spills to a frequency not exceeding 1 in 10 years, and to minimise the potential for seepage losses to groundwater.

5.2.13 Closing Knowledge and Information Gaps

Support projects and co-invest in programs that aim to fill knowledge and information gaps and address limitations identified in Section 4.2 and Appendix VIII of this report.

6.0 COST- BENEFIT – RISK ASSESSMENT

6.1 COSTS OF DEGRADATION

6.1.1 Salinity and Turbidity

The National Land and Water Resources Audit (Hajkowicz and Young 2002) estimated the present value of various types of degradation in Queensland for a 20 year period (2000-2020):

- downstream infrastructure damage costs associated with declining water quality associated with worsening salinity is between $13-26 million (5-10% discount rate);
- present value of increases in water treatment costs due to rising levels of turbidity is $278-307 million (5-10% discount rate);

- present value of salinity cost increases to agricultural production $37 - 54 million (3-6% discount rate).

Considering the level of salinity hazard within the Burnett region, it could be expected that these costs would be disproportionate to the area of region as a percentage of the state.

6.1.2 Weeds

The cost of weeds to agricultural industries alone in Australia has been conservatively estimated at over $3.3 billion per annum. ABARE statistics indicate that the cost of weeds to the livestock industries in Australia is $1.8 billion per year in lost production, and $315 million per year in control costs. The imbalance between these figures reflects the lack of effective or economic control methods for many weeds of grazing land. Weeds cost the Queensland rural community an estimated $500 million annually in lost production and control, and also affect human health, recreation and the environment. The costs to Queensland of just two of the major terrestrial weed plants in the Burnett-Mary region give an indication of the severity of the problem:

- Lantana, which is toxic to livestock, is estimated to cause $7.7 million in annual stock losses in Queensland. The control cost to primary industries is in excess of $10 million per year.
- Parthenium weed is unpalatable to livestock and potentially toxic if force-fed. Cattle, goats and buffaloes have been poisoned experimentally in India, but there are no records of toxicity of livestock under normal grazing conditions in Australia, probably because the doses needed for toxicity would not be eaten naturally (Ahmed *et al.* 1988a,b). It causes serious allergenic reactions in humans. It has major impacts on both the grazing and cropping industries, with estimated losses of $16 million per year for pastoralists.

6.2 BENEFITS OF SUSTAINABLE PRODUCTION

6.2.1 Pest Management

A recent economic assessment in Queensland has shown that:

- every $1 spent on pest prevention yielded a return of $31 in benefits;
- eradication of newly established weeds yielded a benefit cost ratio of 16:1; and
- containment of widely established weeds such as prickly acacia and rubber vine had a benefit cost ratio of about 2:1

6.2.2 Remnant Retention

The Australian Office of Greenhouse (2003) has conducted a preliminary assessment of the greenhouse gas benefits of the proposal to phase out clearing remnant vegetation in Queensland. The proposal could deliver a green house outcome of up to 25 megatonnes carbon dioxide (CO_2) abatement per annum for less than $1 per tonne of CO_2. Rolfe (2002) has suggested that the value of green house emissions from not clearing eucalypt woodlands ranges from$28 to $233 per hectare. Such gains must be weighed against the opportunity costs of forgone clearing which has been estimated at $181 million for a cessation of clearing of “of-concern “vegetation throughout Queensland, assuming all clearing is for pastoralism” (ABARE, 2003).

6.2.3 Consumer’s Willingness to Pay

“Willingness to Pay” is an economic measure that approximates the value the community places on an asset/ product. Retaining native vegetation can provide substantial benefits

(Gillespie 2000, Miles *et al.,* 1998). Native vegetation can provide direct benefits to landholders by providing shelter and shade for stock, grazing and firewood. Long-term sustainability of land for agricultural use can also be improved by preventing erosion and salinity. This can benefit both landholders and the broader community. The value of the direct benefits to landholders has been estimated by Miles *et al*. (1998) as being $36 /ha in the Victorian sample and $630/ha in NSW. The community's 'Willingness to Pay' (WTP) for various sustainable outcomes has been estimated by various authors, including:

- Lockwood and Carberry (1998) estimated the community value of native vegetation at $760/ha. (Hill 2002).
- The results of the study by Rolfe *et al.* (2003) indicated that the wider community in Queensland does have substantial preservation values for regions with native vegetation. The WTP to maintain endangered species in the desert uplands region was $11.39 per species, the WTP to avoid each 1% loss in non-threatened species was $1.69 and the WTP to avoid each 1% loss in the area of unique ecosystems was $3.68.

Preserving forests is a cost-effective way to provide clean drinking water because forests reduce landslides, erosion and sediment transport, improve water purity by filtering pollutants, and in some cases capture and store water. One recent evaluation showed it would cost US$7 billion to build a water treatment plant as against a $1 billion bill for actively managing the forest catchment area by raising water taxes and paying farmers to use less fertilizer and reduce grazing (ABC 2003).

6.2.4 Cost Benefit Analysis of Dairy Effluent Assistance Project

This project provided effluent system auditing, technical and design advice and small grants of 30% of costs (to a maximum level of $3000) for installation of best practice effluent management systems. Farmers reported the following short-term benefits flowing from the new systems included:

- reduced time/labour in cleaning pits;
- sustainable year long grass growth;
- reduction in muddy ground around yards increasing area of land for grazing;
- overall farm productivity improved;
- decreased fertiliser load (replaced fertilizer completely in some areas);
- increased milk production;
- less irrigation from the Mary River.

It was estimated the project managed and reused nutrients of a equivalent fertilizer value of:

Nitrogen	54 720 kg of Urea
Phosphorous	66 000 kg of Super
Potassium	16 480 kg of KCL.

6.3 BENEFIT-RISK ANALYSIS

It is outside the scope of this paper to conduct a detailed cost –benefit analysis of recommendations. However, material discussed in this paper can be used to prioritise implementation proposals based on broad socio-economic appraisal and ecological risk assessment. The process has adapted approaches undertaken in the SEQ Western Catchments Draft Regional Plan (SEQ Western Catchments Group Inc. 2004). The contributors to the

paper formed an expert panel for the purpose of workshopping this process and based ranking on their professional experience and knowledge and the combined input in the draft paper. An integrated 6-step prioritisation process was used in determining the priority of the proposed implementation responses in section 5.2. The result of the value/ threat analysis is given in Figure 6.1 and Table 6.1.

Figure 6.1. Significance of sustainable primary production: An analysis of the magnitude of threat.

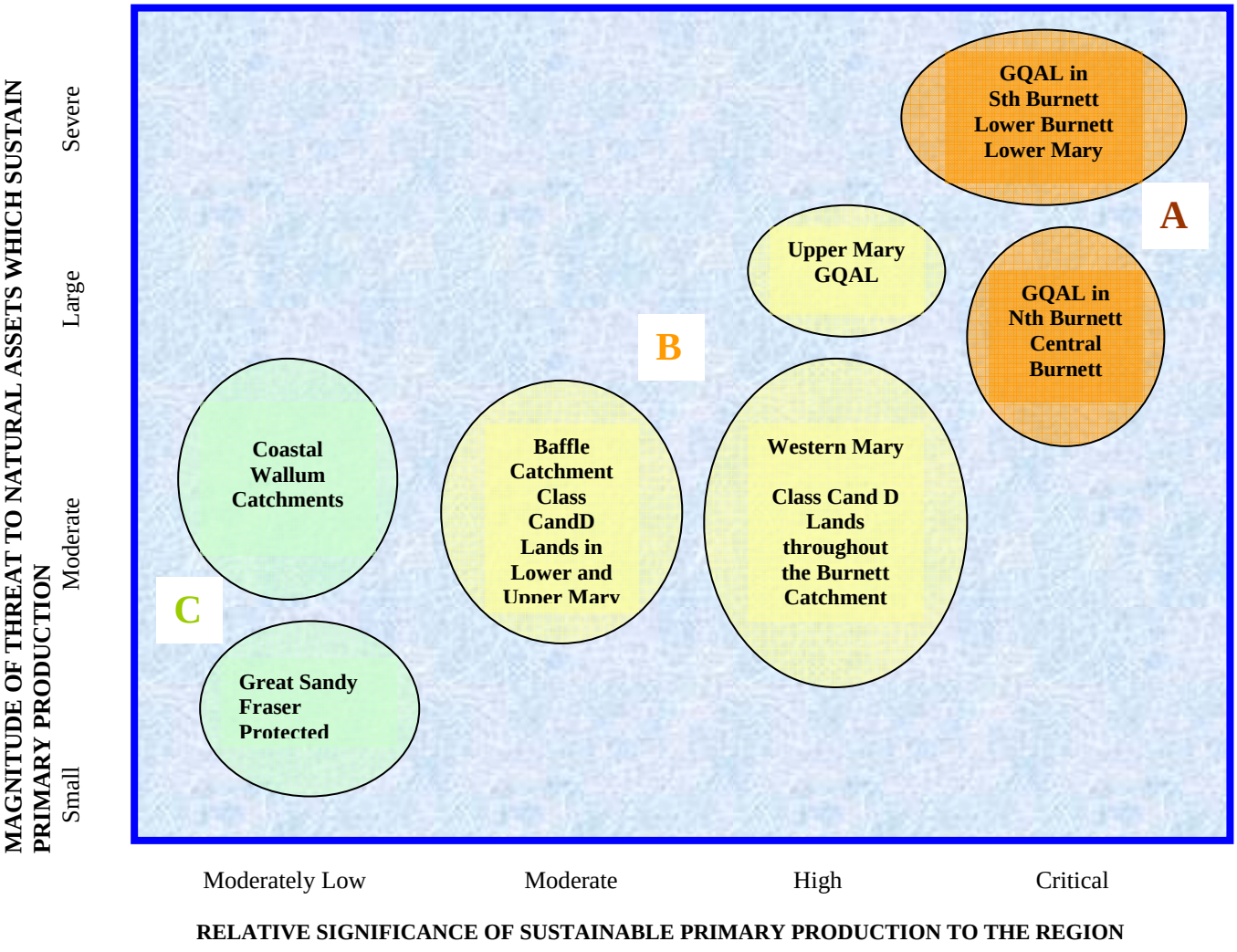


Table 6.1 shows the result of the value/ threat analysis in Figure 6.1.

Table 6.1. Sub-Regions with similar asset significance and degree of threat

Sub-regions	Asset-Threat Classification	River /Ck Catchments
A	Critical asset – high to very high threat	Good quality agricultural lands (GQAL) in: South Burnett Lower Burnett Lower Mary (irrigation scheme area) North Burnett Central Burnett
B	Moderately high value assets and moderately high threats	GQAL upper Mary (Cooloola Shire south) Western Mary subcatchments (Glastonbury Creek north) Baffle catchment Class C & D lands in Burnett catchment Lower Mary Upper Mary
C	Low value assets with low to moderate threats	Coastal wallum catchments Great Sandy and Fraser Is. (protected areas)

In order to easily identify individual responses identified in section 5.2, code names have been assigned as per Table 6.2 below:

Table 6.2. Codes used for the implementation responses.

IMPLEMENATION RESPONSE RECOMMENDATION	CODE NAME
5.2.1 Establish a Brokerage for Market Based Instruments	MBIs
5.2.2 Establish a Funding Stream for Ecosystem Service Payments	Eco Services
5.2.3 Implement Sustainable Production Systems Partnerships	SP System
5.2.4 Expand Rural Water Use Efficiency Projects and Run Off Monitoring	Water
5.2.5 Nutrient Management Program	Nutrients
5.2.6 Reduce Impacts of Pesticides and Chemicals	Chemicals
5.2.7 Natural Area and Riparian Management Program	Natural Area
5.2.8 Implement 'Best Bet' Weed Strategies Terrestrial Weeds	Weeds
5.2.9. Encourage the Application of Bioremediation and Recycling Technologies	Bioremedy
5.2.10 Sustainable Forest Management Package	Forestry
5.2.11 Grazing Land Management	Grazing
5.2.12 Intensive Livestock Action Plan	ILS Action
5.2.13 Closing Knowledge and Information Gaps	Info Gaps

Table 6.3 uses an assessment of the level of likely benefit flowing from the response compared to the relative risk associated with its implementation in each of the identified sub-regions. The priority groupings however, are based on an assumption that a degree of risk aversion is required to justify investment. It should be noted that some responses, which may represent a very high or severe risk of not achieving the desired level of biodiversity gain, may also represent the best bet strategy for addressing the key threats. Failure to implement any responses to address these threats may result in high costs to future generations as the

problem exacerbates. A strategy considering responses which address threats that have a "high cost of doing nothing" is recommended. The lowest priority is assigned to responses in regions where they are considered to have minimal benefit or very high implementation risks and associated potential moderate gains in biodiversity. It is proposed that these responses be reviewed if catchment conditions change or new knowledge reduces the risk or increases the benefit of interventions.

Table 6.3. Priority ranking for implementation responses for the sub-regions

Priority Ranking	Sub-region A	Sub-region B	Sub-Region C
Priority 1 **Very Highly Recommended**	5.2.3 SP System	5.2.3 SP Systems 5.2.11 Grazing	5.2.2 Eco Services
Priority 2 **Highly Recommended**	5.2.4 Water 5.2.5 Nutrients 5.2.6 Chemicals 5.2.9 Bioremedy 5.2.10 Forestry 5.2.12 ILS Action 5.2.13 Info Gaps	5.2.2 Eco Services 5.2.9 Bioremedy 5.2.12 ILS Action 5.2.13 Info Gaps	5.2.13 Info Gaps
Priority 3 **Recommended**	5.2.7 Natural Area 5.2.8 Weeds	5.2.1 MBIs 5.2.5 Nutrients 5.2.6 Chemicals 5.2.10 Forestry	5.2.5 Nutrients 5.2.6 Chemicals
Priority 4 **Consider High Cost of Doing Nothing**	5.2.2 Eco Services	5.2.7 Natural Area 5.2.8 Weeds	5.2.7 Natural Area 5.2.8 Weeds
Priority 5 **Review if benefits or risk change**	5.2.1 MBIs 5.2.11 Grazing	5.2.4 Water	5.2.1 MBIs 5.2.3 SP System 5.2.4 Water 5.2.9 Bioremedy 5.2.10 Forestry 5.2.11 Grazing 5.2.12 ILS Action

7.0 MONITORING AND EVALUATION PROGRAM

7.1 GENERAL

1. Undertake monitoring at the various property, catchment and regional scales by local, catchment and regional groups; and across the State by agencies. Develop a coordinated and flexible system that operates at the various levels including:

- property scale linked to property management plans, private resource targets and quality assurance (QA) systems;
- catchment and regional scale by agencies and community groups; linked to regional priorities and resource targets and satisfying needs off all stakeholders;
- State-wide; coordination between regional groups and state and federal agencies to meet legislative requirements and State of the Environment reporting.

7.2 FORESTRY

2. Establish a region-wide forest health monitoring network and set of terrestrial bio-indicators which are sensitive to ecosystem responses to land use change. Base bio-indicators on research work proposed in Section 5. Include forests types/ species representative of various landscape elements from ridge top recharge areas, mid-slope transition zones, floodplain discharge areas and riparian fringes.

3. Establish forestry and grazing demonstration sites to provide long-term models of best practice land use. Long-term monitoring and involving landowners in action research to compare productivity with that from traditional practice would be an essential step.

7.3 GRAZING

1. Build a broader network of QGraze and TRAPS monitoring sites throughout the region and link to the state-wide database. Extract and interpret existing data from these sources to inform responses.

7.4 HORTICULTURE, CANE AND CROPPING

1. Establish Integrated Area Wide Monitoring Networks with broad industry involvement, peer review of monitoring results, peer advice and pressure to respond to problems. Provide confidentiality to property level results to build trust, but provide incentives for passing on local area data to Landcare and sub-catchment data to Catchment Groups and the Regional Body.

2. Implement a monitoring project to assess 'clusters' of horticultural, cane and cropping enterprises to assess the nature, extent and severity of off-site impacts of these industries. For example, monitor a group of 5 neighbouring farms with no/limited cane, with similar 5 properties in the same area with cane.

7.5 INTENSIVE LIVESTOCK

1. Actively involve enterprises in Waterwatch networks and the like to monitor stream water quality in adjacent waterways above and below intensive enterprises.

2. Enhance capacity of producers to identify vegetation indicators of nutrient enrichment on-site and in riparian and aquatic plant communities.

7.6 WEEDS AND PEST ANIMALS

1. Collective Local Government Area Pest Management Plans could form the basis for the development of regional weed management targets and evaluation of specific pest management strategies.

REFERENCES

(Including citations within Appendices)

ABC (2003). *Science Online*, *Running Pure*. 2 September www.panda.org/.

Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) (1997). National Guidelines for Beef Cattle Feedlots in Australia, 2nd Edition, Standing Committee on Agriculture and Resource Management, Report No. 47, CSIRO Publishing, Collingwood, Vic.

Ahmed, M.N., Rao, P. R. and Mahendar, M. (1988a). Experimental introduction of acute toxicity in buffalo calves by feeding Parthenium hysterophorus Linn. Indian Journal of Animal Sciences. **58** (6) 731-734.

Ahmed, M. N., Rao, P. R. and Mahendar, M. (1988b). Is *Parthenium hysterophorus* L. an obnoxious weed? Indian Journal of Animal Sciences **58** (6) 731-734.

Anon (2001). Environmental Code of Practice. Department of Primary Industries, Information Series QI01049, Brisbane

Anon (2002) Subtropical dairying better practices checklist. Department of Primary Industries. Information Series QI02061, Brisbane

Anon (2004). Hardwoods Queensland. Research and development to support Queensland's hardwood industries: www.dpi.qld.gov.au/hardwoodqld

Australian Bureau of Agricultural and Resource Economics. (2003). Queensland Land Clearing Proposal: Social-Economic Impact. Report to the Commonwealth Government, Dept of Agriculture Fisheries and Forestry Australia.

Australian Office of Greenhouse (2003). Queensland Land Clearing Proposal Greenhouse Gas Benefits. Submission to Productivity Commission, 2003.

Australian Pork Limited (2003). PigStats, Pig industry statistics. APL. http://www.apl.au.com/publications/pigstats.htm

Australian Pork Limited (2002). Draft National Environmental Strategy for the Pig Industry. July 2002, APL, Deakin West, ACT.

Attiwell, P.M. (1994). Ecological disturbance and the conservative management of eucalypt forests in Australia. Forest Ecology and Management, **63**: 301-46.

Azzopardi. M. (2001). Compass: A Self-Assessment Workbook. Bureau of Sugar Experiment Stations, Indooroopilly, Brisbane Qld.

Barraclough and Co. (1999). Farms within the Queensland Horticultural Industry. Audit of Water and Irrigation Use Efficiencies. Final Report. Barraclough and Co.

Bell, M.J. and Bridge, B.J. (2001). Management of compaction on Red Ferrosols used for dryland cropping. Proc., Australian Society of Soil Science Refresher Course, Toowoomba 2000

Bell, M.J., Bridge, B.J., Harch, and Orange, D.N.. (2003a). Rapid rates of internal drainage in Red Ferrosols represent a significant risk for dryland salinity. In: Where is the water and salt going a*nd what is it doing?* – 2nd workshop hosted by the Northern Murray Darling Basin Water Balance/ Deep Drainage Group. Narrabri, November 2003.

Bell, M.J., Bridge, B.J., Harch, G.R., Want. P.S., Orange, D.N and Connolly, R.C. (2001c). Improved soil structure has unexpected effects on the water balance of cropped Ferrosol soils in the inland Burnett. 10th Australian Agronomy Conference, Hobart, Tas. Jan 2001

Bell, M.J., Halpin, N.V., Garside, A.L., Moody, P.W., Stirling, G.R., and Robotham, B.J. (2003b). Evaluating combinations of fallow management, controlled traffic, and tillage options in prototype sugarcane farming systems at Bundaberg. Proc. Aust. Soc. Sugarcane Tech. (25).

Bell, M.J., Halpin, N.V., Orange, D.N. and Haines, M.J. (2001a). Effect of compaction and trash blanketing on rainfall infiltration in sugarcane soils. Proc. Aust. Soc. Sugarcane Tech. (23):161 – 167.

Bell, M.J., McLaughlin, M.J., Barry, G.A., Halpin, N.V. and Cozens, G.D. (2001b). Impact of crop and soil management on accumulation of Cadmium by peanut and soybean. 10th Australian Agronomy Conference, Hobart, Tas. Jan 2001.

Bell, M.J., McLaughlin, M.J., Wright, G.C. and Cruickshank, A. (1997). Inter- and intra-specific variation in the accumulation of cadmium by peanut, soybean and navybean. Aust. J. Agric. Res. **48**: 1151-60.

Bell, M.J., Moody, P., Connolly, R. and Bridge, B. (1998). The role of active fractions of soil organic matter in physical and chemical fertility of Ferrosols. Aust. J. Soil. Res. **36:** 809-819.

Biswas, A.K., Tortajada, C. (1995). Environmental management in Cameroon: A participatory approach, The Courier ACP-EU, No.153 September-October 1995, pp 85-86.

Bramley, R., Ellis, N., Nable, R. and Garside, A. (1996). Changes in soil chemical properties under long term sugarcane monoculture and their possible role in sugarcane yield decline. Aust J. Soil Res., **34:** 967-984.

Brodie, J., McKergow, L., Prosser, I., Furnas, M., Hughes, A.O. and Hunter, H. (2003). Sources of Sediment and Nutrient Exports to the Great Barrier Reef World Heritage Area (in print).

Bubb, K.A., and Croton, J.T. (2002). Effects on catchment water balance from the management of *Pinus* plantations on the coastal lowlands of south-east Queensland, Australia. Hydrological Processes. **16** (1): 105-117 Jan 2002.

Buhle, S. (1991). Salinity poses serious threat**.** *Gympie Times***.** 10 September 1991.

Busby, G., Hetherington, G., Itzstein, R. and Johnston, G (2004). Your dairy business – Knowing, understanding and improving your enterprise, QDAS financial and production trends – 2003. DPI (Qld), Information Series QI04024.

Costantini, A., Dunn, G.M. and Grimmett, J.L. (1997). Towards sustainable management of forest plantations in southeast Queensland. II. Protecting soil and water values during second rotation *Pinus* plantation management. Australian Forestry. **60** (4): 226-232.

Campagnolo D., and Lindsay S. (1999) Queensland banana industry – farm chemical use survey. Centre for Wet Tropics Agriculture, South Johnstone, Queensland Horticulture Institute, Agency for Food and Fibre Sciences, DPI, Queensland. Final Report FR96022, 15 November 1999.

ChemCert Australia. http://www.chemcert.org.au/index.shtm

Claridge, J., Williams, K., Grundy, M., Wilkinson, K., Bell, M., Storey, R., Ryan, P. and Ward, D. (2001). The use of modelling tools to investigate catchment water balance and eucalypt plantations in the Burnett. Final Report 2001. Enhance Resource Assessment 2001-02, Natural Resources and Mines, Brisbane.

CRC Reef Research Centre (2001) Land Use and the Great Barrier Reef World Heritage Area, Current State of Knowledge. http://www.barrierreef.org/publications/files/CRC_Reef_run-off_brochure.pdf

Cunningham, S. and Whitwell, R. (2001). Viability of Recycling and Reprocessing Trickle Tape/Plastic Mulch, Central Queensland University Report, Dec. 2001.

Curtis A, De Lacy T. (1997). Examining the assumptions underlying Landcare. In Lockie, S, and Vanclay F, (eds) *Critical Landcare*. Key Papers Series, No 5, Wagga Wagga: Centre for Rural Social Research, Charles Sturt University. pp 185-199.

Department of Agriculture, Forestry and Fisheries (2004). Pathways to EMS. http://www.horticulturefortomorrow.com.au/

Department of Natural Resources (1999). Burnett River Catchment State of the Rivers Report. Brisbane.

Department of Natural Resources and Mines (2003). Baffle Creek Catchment State of the Rivers Report. Brisbane.

Department of Natural Resources and Mines. PestInfo. http://www.nrm.qld.gov.au/pests/pestinfo/

Department of Primary Industries (1989). Queensland Government Guidelines for the Establishment and Operation of Cattle Feedlots. QDPI. 1 Sept 1989.

Department of Primary Industries and Fisheries (2004a). Agricultural Employment Statistics South East Queensland, Agricultural performance system sub project working papers. Internal DPI&F Reports. Brisbane.

Department of Primary Industries and Fisheries (2004b) South East Queensland Regional Economic Analysis, Agricultural performance system sub project working papers. Internal DPI&F Reports. Brisbane.

Department of Primary Industries and Fisheries. MACMAN. http://www.dpi.qld.gov.au/macman/

DeRose, R. Prosser, I. Wilkinson, L. Hughes, A. and Young, W. (2002). Regional Patterns of Erosion and Sediment and Nutrient Transport in the Mary River Catchment, Queensland, Technical Report 37/02, CSIRO Land & Water, Canberra.

DrumMUSTER. Developed by The NFF, Avcare, VMDA and the Australian Local Government Association (ALGA). http://www.drummuster.com.au/

Environmental Protection Agency (EPA) (2002). Code of practice for native forest timber production. Environmental Protection Agency, Queensland.

Fertilizer Industry Federation of Australia Inc. (FIFA). FERTCARE. http://www.fifa.asn.au/

Florence, R.G. (1996). Ecology and Silviculture of Eucalypt Forests. CSIRO, Melbourne, Australia

Garside, A.L., Watters, T.S., Berthelsen1, J.E., Sing, N.J., Robotham, B.G. and Bell, M.J. (2004). Comparisons between conventional and alternative sugarcane farming systems which incorporate permanent beds, minimum tillage, controlled traffic and legume fallows. Proc. Aust. Soc. Sugarcane Tech., 26 (in press).

Gillespie Economics (2000). Economic Values of Native vegetation in NSW. Background Paper No. 4. Native Vegetation Advisory Council DLWC Sydney.

Hajkowicz, S. and Young, M. (2002). Value of Returns to Land and Water and Costs of Degradation: Final report to National Land and Water Resources Audit. CSIRO Land and Water.

Haynes, D. Morris, S. (2003). Water Quality In: Chin, A. (ed) *State of the Great Barrier Reef on-line.* Great Barrier Reef Marine Park Authority, Townsville. (Viewed on 24/02/04), http://www.gbrmpa.gov.au/corp_site/info_services/publications/sotr/water_quality/index.html

Haynes, D., Muller J., and Carter S. (2000). Pesticide and herbicide residues in sediments and seagrasses from the Great Barrier Reef World Heritage Area and Queensland coast. Marine Pollution Bulletin **41**: pp. 279-287.

Henry, N.B. (1960), The effect of silvicultural treatment on the production from native forests. Australian Forestry. **24** (1): 30-45.

Henry, N. B. and Florence, R. G. (1966). Establishment and development of regeneration in spotted gum – ironbark forests. Australian Forestry **30**, 304 – 316.

Hill, C. (2002). Major socio-economic issues identified from consultant reports of regional vegetation management plans. Native Vegetation Advisory Council DLWC Wagga Wagga.

Hoong Pung (2003). Investigation of soil factors associated with the productivity and sustainability of vegetable production in Australia. Final Report, Horticulture Australia Project No. VG99057.

House, A. (1995). Fire Ecology Research in Queensland Native Forests – Current Status and New Directions. Procedings of the 7th Queensland Fire Research Workshop: 39-48.

Hunter, H. and Armour, J. (2001). Measurement and prediction of agrochemical movement in tropical sugar cane production key findings nutrients - ACIAR project 9446, NR&M Bundaberg Seminar May 2001.

Intergovernmental Science Panel. (2003). A Report on the Study of Land-sourced Pollutants and their Impacts on Water Quality in and Adjacent to the Great Barrier Reef. Office of the Chief Scientist. Department of Primary Industries, Brisbane.

Johnson, D. (1997). State of the Rivers - Mary River & Tributaries. Department of Natural Resources, Brisbane.

Johnston, P.J.M. and Wylie,F.R. (1984). Casuarina dieback in the Mary River Catchment. Queensland Agricultural Journal, Vol **110**, No. 1.

Lamb, D. (1986) Forestry. In Russell, J.S. and Isbell, R.F. (eds.) Australian Soils: The Human Impact. University of Queensland Press, Brisbane.

Land resource Assessment and Management Pty Ltd. (2004). State of Region Study: Draft Final Desktop Review Version 3. Burnett Mary Region Natural resource Management Group Inc.

Lawrence, G., Richards, C., Herbert-Cheshire,L. (2002). The Environmental Enigma: Why Do Producers Professing Stewardship Continue to Practice Poor Natural Resource Management? Xth Agrifood Research Network Meeting and Biotechnolgy Symposium, Akaroa, Canterbury, New Zealand, 21-24 April 2003.

Lindenmayer, D. (1999). Uneven-aged stands and forest biodiversity. Paper presented to the Second Research Colloquium, Australian National University, Canberra. 15-16 March, 1999.

Lockwood, M and Carberry D (1998). State Preference Surveys of Remnant Vegetation Conservation. Johnson Centre Report No. 102 CSU Albury.

Mary Valley Sunshine Coast Farm Forestry Association (in prep). Private Native Forest Management in the Mary and Burnett Catchments. NHT Project.

Meat and Livestock Australia (2000). National Beef Cattle Feedlot Environmental Code of Practice.(MLA, June 2000).

Miles C, Lockwood M, Walpole W and Buckely E (1998). Assessment of on-farm economic values of remnant native vegetation. Johnson Centre Report No, 107 CSU Albury.

Moody, P.W., Bramley, R.G.V., Skjemstad, J.O., Garside, A.L. and Bell, M.J. 1999. The effects of fallow and break crops on the quantity and quality of organic matter in cane soils. pp. 87-91. In: Proc., 21st Conference of the Australian Society of Sugar Cane Technologists, April 1999 (Townsville).

Mulo, S. (1999). MacMan: a farm recording system for macadamia, (CD-ROM), Department of Primary Industries and Fisheries, Queensland

National Land and Water Resources Audit (2001). Australian Agriculture Assessment 2001 http://audit.ea.gov.au/anra/agriculture/docs/national/Agriculture_Contents.html

Nielson C and Olivia N (2003). DairySAT - Dairying for Tomorrow. Department of Primary Industries, Ellinbank, Victoria

Nelson, R., Alexander,F. Elliston, E. Blias, A. (2004). Natural resource management on Australian farms. ABARE eReport 0.47. DAFFA , Canberra..

Preen. A.R. (1995). Unprecedented die-off of seagrass and dugongs in Hervey Bay resulted from Mary River floods and associated cyclone. In: Hunter,H., Eyles, A, and Rayment, G. (eds.) Downstream Effects of Land Use. Department of Natural Resources Brisbane.

Productivity Commission (2003). Industries, land use and water quality in the Great Barrier Reef Catchment. Research Report, Canberra.

Pusey, B.J., Arthington, H. and Read, M.G. (1993). Spatial and temporal variation in fish assemblage structure in the Mary River, south-eastern Queensland: the influence of habitat structure**.** Environmental Biology of Fishes **37:** 355-380**.**

QFVG (Queensland Fruit and Vegetable Growers) (1998). Farmcare – cultivating a better future – code of practice for sustainable fruit and vegetable production in Queensland. Rocklea, Queensland.

Rayment, G.E. (1977). Sources of cadmium in agricultural products. Invited paper to National Cadmium Workshop, May 1995. pp.35. Department of Primary Industries and Energy Australia, Canberra.

Reeve, I. (2001). Australian Farmers' Attitudes to Rural Environmental Issues. Land and Water Australia and the Rural Industries Research and Development Corporation, Canberra, July.

Rolfe. J., Blamey. R. and Bennett. J. (2003). Valuing the preservation of rangelands: tree clearing in the desert uplands region of Queensland. In press.

Rolfe. J. (2002). Economics of vegetation clearing in Queensland. Rangeland Journal **24** (1): 152-169.

Ross, Y. (1998). Hollow trees and habitat management in south-east Queensland. Resource Science and Knowledge, Department of Natural Resources, Brisbane, Queensland.

Ryan, S. and Taylor, D.W. (2002). Private native forest productivity, is it the key to the future of Queensland's timber industry? Proceedings of the 2002 Australian Forest Growers Association, Albany.

Sattler, P. and Williams, R. (1999). The Conservation Status of Queensland's Bioregional Ecosystems. Environmental Protection Agency, Queensland.

Schroeder, B.L. Wood, A.W. Kingston, G. (1998). 'Re-evaluation of the basis for fertiliser recommendations in the Australian sugar industry', Aust. Soc. Sugar Cane Technol. 20 Proc., pp. 239-247.

Simpson, B. and Ham, G. (2001). Measurement and prediction of agrochemical movement in tropical sugar cane production key findings pesticides, Bundaberg Seminar May.

Skerman, A. G. (2000). Reference Manual for the Establishment and Operation of Beef Cattle Feedlots in Queensland, Queensland Cattle Feedlot Advisory Committee (FLAC), DPI, Qld, Information Series QI99070.

Smith, G. (1994). How do farmers in the Inland Burnett prefer to learn? Unpublished report DPI Kingaroy.

Smith D. (2001) Introduction and assessment of overseas beneficial for biocontrol of citrus soft scale 1 July 1992 – 30 June 2001. HRDC Final Report 2: C7519 and CT98038.

SEQ Western Catchments Group Inc. (2004). Healthy Land – Our Futre. Integrated regional natural resource management plan for the Western Catchments of south-east Queensland. Draft for public consultation. SEQ Western Catchments Group Inc. http://www.healthylandourfuture.com.au/

Stirling G.R. (2004). Suppressive soils for biological control of root-knot nematodes on vegetable crops. Current Horticulture Australia Project No. VG01087.

Stockwell, B.R. (1996) State of the Environment Report: Cooloola Conservation Strategy, Volume 2. Cooloola Shire Council, Gympie.

Stockwell, B.R. (2001) Mary River and Tributaries Rehabilitation Plan. Mary River Catchment Coordinating Committee, Gympie.

Streeten, T. A. and McGahan, E. J. (2000). Environmental Code of Practice for Queensland Piggeries. DPI, QI00048.

Sugar Research and Development Corporation (a) (current). GrubPlan 2: Developing improved risk assessment and decision-support systems for managing greyback canegrub. SRDC funded project. http://www.srdc.gov.au/index.html

Sugar Research and Development Corporation (b) (current). Accelerated adoption of best practice nutrient management. SRDC funded project http://www.srdc.gov.au/index.html

Sugar Research and Development Corporation (2005). Delivery of training for farm management systems for the sugarcane industry. Terms of reference. http://www.srdc.gov.au/Sugar_Industry_FMS_3_Terms_of_Reference.doc

Synapse Research and Consulting (2004). The Australian Land Management System (ALMS) Information and resource website. http://www.synapseconsulting.com.au/

Taylor, D (1996). Preliminary report on the impact on soil physical properties associated with native forest harvesting in Yielo L.A., S.F. 788 Sunday Creek. Internal Report. DPI, Queensland Forestry Research Institute, Gympie, Queensland.

Taylor, D and Annandale, M. (2000). Management of Private Native Forests Part 1. Silviculture for Private Native Forest in Queensland. Paper presented to the Australian Forest Growers Conference, 4-6 September 2000, Cairns.

Taylor, D (2003). Silvicultural standards for private native forest. A discussion paper prepared for the Timber Task Force. Department of Primary Industries, Gympie, Qld.

Thorburn, P.J. Park, S.E., Biggs, I.M. (2003). Nitrogen fertiliser management in the Australian sugar industry: strategic opportunities for improved efficiency. Aust. Soc. Sugar Cane Technol. **25**: Proc. (Abstracts). 22.

Tothill, J. and C. Gillies (1992). The pasture lands of northern Australia: their condition, productivity, and sustainability. St Lucia, Brisbane, Tropical Grasslands Society of Australia Inc.

Ulloa, P. and Bunbury, R (2002). Enviroveg Program. Vegetable Growers Association of Victoria.

Vanclay F. and Lawrence G. (1995). The environmental imperative: eco-social concerns for Australian agriculture. Central Queensland University Press, Rockhampton.

Weston E.J., Harbison J, Leslie J.K., Rosenthal K.M. and Mayer R.J. (1981).Assessment of the agricultural and pastoral potential of Queensland.' Queensland Department of Primary Industries Agricultural Branch, 27, Brisbane, Qld.

Wylie, F.R., Johnston, P.J.M. and Eisemann, R.L. (1993a*).* A survey of native tree dieback in Queensland. DPI Queensland Forestry Research Institute Research Paper No.16. 100 pp.

Wylie, F.R., Johnston, P.J.M. and Forster, B.A. (1993b). Decline of Casuarina and Eucalyptus in the Mary River catchment. DPI Queensland Forestry Research Institute Research Paper No.17. 32pp.

APPENDIX I

OVERVIEW OF ECONOMIC IMPORTANCE OF PRIMARY PRODUCTION & FISHERIES TO THE BURNETT MARY REGION

PRIMARY PRODUCTION OVERVIEW

Extensive grazing on freehold titles constitutes some 69% of land use in the Burnett Mary (Land resource Assessment and Management Pty Ltd. 2004). When grazing on state forest, special leases and rural residential land is included, the area increases to approximately 80%. The grazing industry therefore is a major stakeholder in the management of remnant vegetation and is a significant gross contributor to potential salinity and water quality issues.

In Queensland, the forestry industry includes growing operations on state and private land, in native forest and plantations as well as commercial timber processors. The forest processing industry is privately owned, ranging from small family businesses to listed corporations. The Burnett and Mary catchments contain the most productive land in terms of soil and climate for timber production in the state. There is a significant exotic pine plantation estate totalling 75 000 ha in the Mary and coastal catchments as well as a rapidly developing hardwood plantation industry in both catchments, and particularly in the south Burnett (Anon 2004). As demand for timber increases, the plantation resource will be required to replace a resource previously sourced from native forest areas.

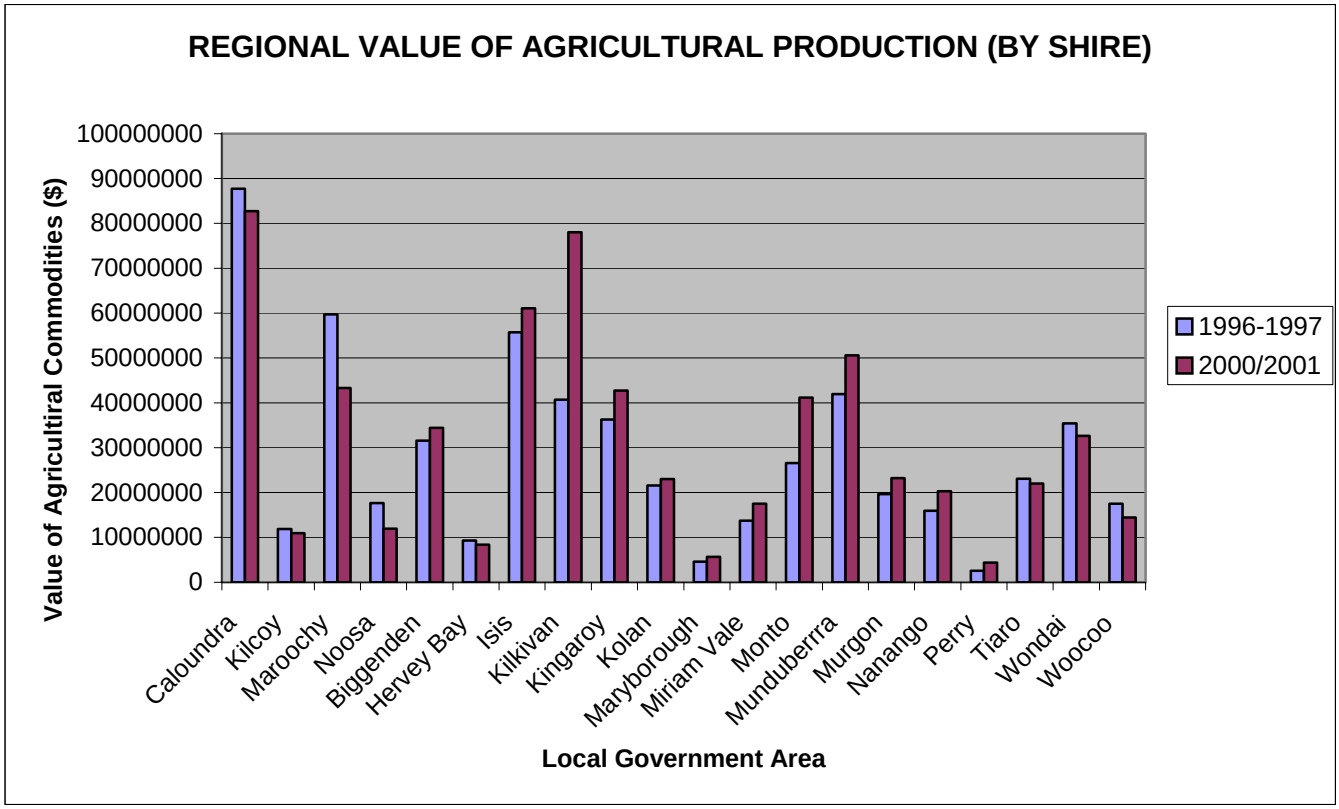
Intensive livestock production industries make very important contributions to the economies of many communities in the Burnett-Mary River region. The pork, beef cattle feedlot and dairy industries (and to a lesser extent, the egg and meat chicken industries) are all major rural industries in the region. They provide direct employment in the production and processing sectors of each industry and significant indirect economic benefits to the local communities by the purchase of commodities and livestock and through the use of service industries.

The Burnett-Mary has 17% of the State's 400 feedlots, accounting for approximately 10% of the State's feedlot cattle capacity. This means that Burnett-Mary is the third most intensive lot-feeding region in Queensland, after the Darling Downs and Central Highlands. There are approximately 256 dairy farms in the region each milking an average of approximately 140 cows. This represents approximately 25% of the State's dairy farms and milk production.

The region also accounts for approximately one third of the State's pig production, and is the second highest pig production region after the Darling Downs. Egg and chicken meat production in the Burnett-Mary are both significant but not major industries from a State or National perspective. Based on DPI&F data, there are approximately 9 egg producers in the catchment with a total of 76 000 birds. From a State perspective, this represents 9% of the egg producers and 3% of the laying hens. There are also about 10 meat chicken, turkey, duck and squab producers in the catchment with approximately 193 000 birds.

The Inland Burnett supports approximately 50 000 ha of rainfed broad-acre cropping. The Office of Economic and Statistical Research (OESR) indicate that the Statewide Gross Value of Production from Fruit and Vegetables (1999/2000 figures) is $1,090.9 million. From approximately only 1% of the total land use of the Burnett/Mary Region the gross value of horticulture in the region was $225.8 million in 2000 (OESR reference, Cunningham and Whitwell, 2001). Yet in 2002 the Bundaberg region alone produced $216 million gross value (DPI&F extension figures, Lovett pers comm, 2002, Bundaberg). This indicates the Bundaberg region constitutes approximately 20% of State's horticultural production.

Agriculture, forestry and fisheries industries still provide an average of 26% of employment in the region (excluding Sunshine Coast Councils areas) and ranging up to 54% of the workforce in the Munduberra Shire. Ensuring this employment is sustainable in the long term would be a high value investment in the economic stability and environmental prosperity of the Burnett Mary Region. In the 2001 Agricultural Census shires within the region (includes some of the SEQ region) recorded nearly $63 million worth of production, which was approximately 9% increase from the 96/97 data. The largest economic producing Shire was Caloundra, but this is largely linked to the poultry industry which is located outside of the part of that shire within the Burnett Mary region. Kilkivan was the next highest performer as identified in Figure 1, which is predominantly related to beef cattle and particularly the large feedlot in that shire.



Source: DPI&F, 2004a,b.

SNAPSHOT OF SE LGA PROFILES

These are listed by Disadvantage Ranking and data are from DPI&F (2004a,b).

Relative Socio-economic Disadvantage Ranking

This is calculated from characteristics such as low income, low educational attainment, high unemployment and jobs in relatively unskilled occupations. The lower the area's ranking the more disadvantaged that area is compared to other areas.

Industry Diversity

If a high percentage of people are employed in one industry then the LGA does not have a very diverse industry base. If something were to happen to this industry then the LGA may be vulnerable.

Median Age

Is the age at which half the population is younger and half the population is older.

Tiaro (S)	Disadvantage Ranking	*Population* 2001	2026
	7	4,672	9,032

Employment

31% Employed in Agriculture, Forestry and Fishing

- 28.4% Beef cattle
- 13.7% Sugar cane
- 19.3% Fruit
- 10.7% Dairy cattle

Population

Prime working age – 2001 **67%**
Prime working age – 2026 **58%**

Median age **41 - 52** (Compared to Queensland: 35 – 42)

Murgon (S)	Disadvantage Ranking	*Population* 2001	2026
	8	3,625	4,757

Employment

18% Employed in Agriculture, Forestry and Fishing

- 23.5% Beef cattle
- 12.2% Dairy cattle
- 18.6% Pigs
- 10.6% Other livestock farming

Population

Prime working age – 2001 **60%**
Prime working age – 2026 **61%**

Median age **31 - 36** (Compared to Queensland: 35 – 42)

Kolan (S)	Disadvantage Ranking	*Population* 2001	2026
	11	4,652	8,342

Employment

35% Employed in Agriculture, Forestry and Fishing

- 31.1% Sugar cane
- 16.3% Beef cattle
- 27.3% Fruit
- 6.2% Other agriculture

Population

Prime working age – 2001 **66%**
Prime working age – 2026 **58%**

Median age **39 - 52** (Compared to Queensland: 35 – 42)

Eidsvold (S)	Disadvantage Ranking	*Population* 2001	2026
	13	941	896

Employment

46% Employed in Agriculture, Forestry and Fishing

- 68.7% Beef cattle
- 10.8% Fruit
- 5.1% Vegetables
- 3.6% Services to agriculture

Population

Prime working age – 2001 **66%**
Prime working age – 2026 **62%**

Median age **38 - 50** (Compared to Queensland: 35 – 42)

Miriam Vale (S)	Disadvantage Ranking	*Population* 2001	2026
	14	4,484	10,107

Employment

21% Employed in Agriculture, Forestry and Fishing

- 40% Beef cattle
- 13.9% Commercial fishing
- 11.5% Forestry and logging
- 11.5% Dairy cattle

Population

Prime working age – 2001 **68%**
Prime working age – 2026 **54%**

Median age **41 - 56** (Compared to Queensland: 35 – 42)

Gayndah (S)	Disadvantage Ranking	*Population* 2001	2026
	21	2,888	2,825

Employment

37% Employed in Agriculture, Forestry and Fishing

- 63.6% Fruit
- 18.8% Beef cattle
- 5.9% Other agriculture
- 3% Services to agriculture

Population

Prime working age – 2001 **64%**
Prime working age – 2026 **65%**

Median age **37 - 45** (Compared to Queensland: 35 – 42)

Nanango (S)	Disadvantage Ranking	*Population* 2001	2026
	22	8,529	11,160

Employment

16% Employed in Agriculture, Forestry and Fishing

- 38.87% Beef cattle
- 10.9% Forestry and logging
- 15.8% Dairy cattle
- 10.3% Fruit

Population

Prime working age – 2001 **64%**
Prime working age – 2026 **53%**

Median age **42 - 55** (Compared to Queensland: 35 – 42)

Mundubbera (S)	Disadvantage Ranking	*Population* 2001	2026
	23	2,298	2,759

Employment

54% Employed in Agriculture, Forestry and Fishing

- 61.3% Fruit
- 4.8% Other agriculture
- 14.4% Beef cattle
- 4.6% Dairy cattle

Population

Prime working age – 2001 **66%**
Prime working age – 2026 **62%**

Median age **37 - 50** (Compared to Queensland: 35 – 42)

Bundaberg (C)	Disadvantage Ranking	*Population* 2001	2026
	24	44,551	58,977

Employment

8% Employed in Agriculture, Forestry and Fishing

- 32.3% Vegetables
- 13.2% Services to agriculture
- 20.1% Sugar cane
- 8.5% Fruit

Population

Prime working age – 2001 **61%**
Prime working age – 2026 **59%**

Median age **37 - 44** (Compared to Queensland: 35 – 42)

Cooloola (S)	Disadvantage Ranking	*Population* 2001	2026
	31	33,651	47,745

Employment

13% Employed in Agriculture, Forestry and Fishing

- 16.1% Beef cattle
- 15.1% Forestry and logging
- 15.1% Vegetables
- 14.7% Fruit

Population

Prime working age – 2001 **64%**
Prime working age – 2026 **58%**

Median age **39 – 49** (Compared to Queensland: 35 – 42)

Kilkivan (S)	Disadvantage Ranking	*Population* 2001	2026
	32	3,222	3,648

Employment

38% Employed in Agriculture, Forestry and Fishing

- 51.8% Beef cattle
- 6.1% Other crop and plant growing
- 11.4% Dairy cattle
- 4.7% Forestry and logging

Population

Prime working age – 2001 **65%**
Prime working age – 2026 **60%**

Median age **41 - 51** (Compared to Queensland: 35 – 42)

Biggenden (S)	Disadvantage Ranking	*Population* 2001	2026
	34	1,554	1,387

Employment

32% Employed in Agriculture, Forestry and Fishing

- 36.1% Beef cattle
- 14.1% Dairy cattle
- 22% Fruit
- 7.9% Grains

Population

Prime working age – 2001 **63%**
Prime working age – 2026 **52%**

Median age **45 - 57** (Compared to Queensland: 35 – 42)

Kilcoy (S)	Disadvantage Ranking	*Population* 2001	2026
	37	3,312	4,294

Employment

20% Employed in Agriculture, Forestry and Fishing

- 39% Beef cattle
- 11% Beef cattle and sheep
- 17.8% Dairy cattle
- 10.6% Forestry and logging

Population

Prime working age – 2001 **63%**
Prime working age – 2026 **52%**

Median age **39 – 53** (Compared to Queensland: 35 – 42)

Maryborough (C)	Disadvantage Ranking	*Population* 2001	2026
	38	25,125	28,318

Employment

3% Employed in Agriculture, Forestry and Fishing

- 30% Forestry and logging
- 8% Beef cattle
- 23% Sugar cane
- 8% Commercial fishing

Population

Prime working age – 2001 **62%**
Prime working age – 2026 **56%**

Median age **40 - 48** (Compared to Queensland: 35 – 42)

Isis (S)	Disadvantage Ranking	*Population* 2001	2026
	41	5,849	7,487

Employment

34% Employed in Agriculture, Forestry and Fishing

- 41.5% Sugar cane
- 17.1% Fruit
- 17.2% Vegetables
- 7.9% Other Agriculture

Population

Prime working age – 2001 **65%**
Prime working age – 2026 **58%**

Median age **43-55** (Compared to Queensland: 35 – 42)

Hervey Bay (C)	Disadvantage Ranking	*Population* 2001	2026
	43	46,298	85,447

Employment

4% Employed in Agriculture, Forestry and Fishing

- 17.9% Beef cattle
- 13.2% Sugar cane
- 16.2% Commercial fishing
- 9.2% Amenity horticulture

Population

Prime working age – 2001 **61%**
Prime working age – 2026 **57%**

Median age **43 - 51** (Compared to Queensland: 35 – 42)

Wondai (S)	Disadvantage Ranking	*Population* 2001	2026
	45	4,229	4,289

Employment

35% Employed in Agriculture, Forestry and Fishing

- 42.9% Beef cattle
- 9.7% Pigs
- 11.7% Grains
- 8.7% Dairy cattle

Population

Prime working age – 2001 **63%**
Prime working age – 2026 **56%**

Median age **41 – 57** (Compared to Queensland: 35 – 42)

Perry (S)	Disadvantage Ranking	*Population* 2001	2026
	48	421	496

Employment

30% Employed in Agriculture, Forestry and Fishing

- 93.9% Beef cattle
- 6.1% Services to agriculture

Population

Prime working age – 2001 **63%**
Prime working age – 2026 **70%**

Median age **42 – 46** (Compared to Queensland: 35 – 42)

Monto (S)	Disadvantage Ranking	*Population* 2001	2026
	66	2,552	1,686

Employment

39% Employed in Agriculture, Forestry and Fishing

- 51.3% Beef cattle
- 7.3% combined grazing and grain
- 15.2% Dairy cattle
- 6.8% Pigs

Population

Prime working age – 2001 **62%**
Prime working age – 2026 **49%**

Median age **42 - 61** (Compared to Queensland: 35 – 42)

Caloundra (C)	Disadvantage Ranking	*Population* 2001	2026
	67	76,207	155,024

Employment

6% Employed in Agriculture, Forestry and Fishing

- 38.5% Fruit
- 7.6% Beef cattle
- 7.9% Dairy cattle
- 7.2% Commercial fishing

Population

Prime working age – 2001 **62%**
Prime working age – 2026 **54%**

Median age **41 - 51** (Compared to Queensland: 35 – 42)

Burnett (S)	Disadvantage Ranking	*Population* 2001	2026
	71	23,891	48,018

Employment

22% Employed in Agriculture, Forestry and Fishing

- 39.7% Sugar cane
- 8.6% Fruit
- 21.6% Vegetables
- 6.6% Other agriculture

Population

Prime working age – 2001 **65%**
Prime working age – 2026 **58%**

Median age **38 - 47** (Compared to Queensland: 35 – 42)

Maroochy (S)	Disadvantage Ranking	*Population* 2001	2026
	91	127.202	267,754

Employment

4% Employed in Agriculture, Forestry and Fishing

- 24% Fruit
- 9% Sugar cane
- 17% Amenity horticulture
- 7% Commercial fishing

Population

Prime working age – 2001 **65%**
Prime working age – 2026 **58%**

Median age **38 - 47** (Compared to Queensland: 35 – 42)

Woocoo (S)	Disadvantage Ranking	*Population* 2001	2026
	94	3,043	4,429

Employment

22% Employed in Agriculture, Forestry and Fishing

- 36.7% Beef cattle
- 8.5% Forestry and logging
- 26.6% Sugar cane
- 5.4% Other agriculture

Population

Prime working age – 2001 **67%**
Prime working age – 2026 **60%**

Median age **38 - 44** (Compared to Queensland: 35 – 42)

Kingaroy (S)	Disadvantage Ranking	*Population* 2001	2026
	96	11,808	14,131

Employment

12% Employed in Agriculture, Forestry and Fishing

- 33.8% Beef cattle
- 8.3% Other agriculture
- 22.1% Grains
- 7.2% Combined grazing and grain

Population

Prime working age – 2001 **63%**
Prime working age – 2026 **60%**

Median age **37 - 46** (Compared to Queensland: 35 – 42)

Noosa (S)	Disadvantage Ranking	*Population* 2001	2026
	112	43,758	60,002

Employment

3% Employed in Agriculture, Forestry and Fishing

- 17.9% Fruit
- 13.4% Amenity horticulture
- 13.6% Beef cattle
- 9.1% Commercial fishing

Population

Prime working age – 2001 **65%**
Prime working age – 2026 **57%**

Median age **41 - 52** (Compared to Queensland: 35 – 42)

APPENDIX II

FORESTRY & GRAZING INDUSTRIES OVERVIEW

FORESTRY

Forestry Industry

The forest processing industry is privately owned, ranging from small family businesses to listed corporations, and processors are located throughout both catchments. The Burnett and Mary catchments contain the most productive lands, in terms of soil and climate for plantation timber production in the state. There is a significant exotic pine plantation estate partly in and adjacent to the Mary catchment and there is a rapidly developing hardwood plantation industry in both catchments, particularly in the south Burnett (Anon 2004). As demand for timber increases, a greater plantation resource is required to replace timber previously sourced from native forest areas. The processing sector in Queensland has developed alongside native forest timber harvests and will look increasingly to future supplies from hardwood plantations. Hardwood species are increasingly valued for hardness, strength, durability as well as unique appearance. Timber Queensland is the industry association facilitating future development and promotion of the forest industry in Queensland.

The timber resource is supplied from both private and state owned land, plantation and native forest. Timber from state forest is sold through a regulated 'allocation' system which is related to sustainable growth rates of the resource. Currently, there is minimal plantation timber available from private land and this is sourced from state plantations. Processors of native forest timbers generally rely on either or both state or private timber for their resource. A summary table of approximate area on forested land in both catchments is set out below (Table1).

Table 1. Approximate area (ha) of forested land in the Burnett and Mary catchments

Forest Type / Catchment	Burnett (ha)	Mary (ha)
State Forest (total)	98,739.82	185,182.91
Private (commercial)	497,407	182,132
Non-commercial	20,152	36,567
Total		

(Source: *NHT Project 'Private Native Forest Management in the Mary and Burnett Catchments. Mary Valley Sunshine Coast Farm Forestry Association*)

Description of Forestry Practiced

The predominant forestry practice undertaken in both catchments is native forest harvesting based on 'selective harvesting' or 'single tree selection' (Florence 1996). Single tree selection has two principal components, harvesting and management of the regenerative and productive potential of the forest. On private land this is a relatively extensive practice as landowners tend to sell timber when in need of funds. Essentially this forestry practice removes only a proportion of the trees at any one time, i.e., only those that have reached a certain size, are of a commercial species and have a commercial product in the bole. Generally, the harvest interval is between 20 to 40 years but may be as low as 10 years for specialty products such as poles. Disturbance levels to the ecology of a forest are relatively low (Attiwell 1994), and generally less than 10% of the forest area is subject to soil disturbance and as little as 4 % is subject to changes in soil properties (Taylor 1996).

Significant work has been undertaken on the impacts of native forest management on water quality and yield particularly in southern Australia. Melbourne Water Board has published a series of reports documenting different aspects of forest management impacts on water yield and quality. Under best practice, water quality is not significantly impacted by forest management activities however water yield has been found to be influenced by age or growth condition of the forest, i.e., young regrowth forests reduce water yield significantly over a period of time. This is consistent with data from regrowth or young plantation forests maximising leaf area index at an early age.

GRAZING LAND

Resource and Production systems overview

The region is split into two bioregions according to geological formations. The Mary catchment and some of the Inland Burnett lie in the Southeast Queensland Bioregion (Sattler and Williams 1999). Parts of Monto, Gayndah, Perry, Wondai and Kingaroy shires, and all of Eidsvold and Mundubbera shires, lie in the Brigalow Belt Bioregion. The major pasture community in the Burnett Mary is the southern black speargrass zone (Weston *et al.* 1981). The blady grass zone occupies the high-rainfall coastal areas. Some minor brigalow communities and *Aristida Bothriochloa* communities exist in the inland and western Burnett catchment.

Management units within grazing land of the Burnett Mary Region are broadly recognised at the operational level by a combination of indigenous vegetation and soil type. Production systems are based on breeding and/or growing and finishing of beef cattle mostly on native pasture. Many properties conduct a combination of these systems. In higher rainfall areas, or on more fertile land types, production systems incorporate sown exotic grasses and legumes. Carrying capacities range from more than 1 adult equivalent (AE) per 2 ha on higher rainfall sown pastures to less than 1 AE to 20 ha on low fertility range country.

The combination of grazing with native hardwood harvesting (both freehold and leasehold land) is significant in several districts. Similarly, grazing combines with more intensive industries such as field cropping and dairying in other districts. In recent decades there has been a trend for grazing land surrounding the major population centres to be subdivided for rural residential allotments. Emerging complementary industries for the grazing industry includes agro-forestry and tourism.

APPENDIX III

INTENSIVE LIVESTOCK INDUSTRIES OVERVIEW

BEEF CATTLE FEEDLOTS

Distribution

DPI&F data indicate that there are currently 67 feedlots that are either licensed or approved under the *Environmental Protection (EP) Act 1994* in the Burnett Mary Region (Table 1). These feedlots have a total capacity of approximately 45 700 standard cattle units (SCU). (A standard cattle unit is defined as an animal of 600 kg liveweight at the time of exit (turnoff) from the feedlot. It is used to describe the capacity of feedlots turning off different classes of cattle at different liveweights, in terms of their manure production. Conversion factors are used to calculate the equivalent number of standard cattle units for a range of cattle liveweights.)

The Kingaroy, Wondai and Kilkivan Shires have the most feedlots, with 12 in each Shire. However, the Kilkivan Shire feedlots are split between the Burnett and Mary catchments.

Table 1. Number and capacities of licensed and approved beef cattle feedlots.

Catchment	Shire	No of Feedlots	Capacity (SCU)
North Burnett	Monto	5	937
	Perry	2	300
		7	**1,237**
Central Burnett	Biggenden	1	50
	Gayndah	1	49
	Mundubbera	2	154
		4	**253**
South Burnett	Kilkivan	6	5,505
	Kingaroy	12	4,495
	Murgon	7	3,295
	Nanango	6	5,321
	Wondai	12	19,755
		43	**38,371**
Lower Burnett	Burnett	1	360
	Isis	1	150
		2	**510**
Burnett		**56**	**40,371**
Central Mary	Cooloola	1	80
	Kilkivan	6	4,800
		7	**4,880**
Lower Mary	Tiaro	3	399
	Woocoo	1	49
		4	**448**
Mary		**11**	**5,328**
Mary - Burnett		**67**	**45,699**

Management Practices

Most of the larger feedlots in the catchment are owned and operated by family companies that are commonly vertically integrated with other sectors of the beef industry, having direct interests or strong links with breeding, processing and/or marketing operations. These large feedlots operate fairly continuously with some fluctuations in animal numbers with changing cattle and grain prices.

Many of the smaller on-farm feedlots in the catchment operate intermittently, on an opportunistic basis, when the relationship between cattle and grain prices, seasonal climatic conditions and the availability of pasture on farm, result in profitable lot feeding. They are commonly owned and operated by a family unit with the majority of cattle being bred on the property. In some cases, the grain, silage and/or hay used in the feedlot ration is produced on-farm.

During extended dry conditions when pasture is depleted and cattle cannot be sustained or finished by grazing, beef producers commonly place grain bins in paddocks to supplement or completely replace the grazed pasture component of the cattle's diet. In these circumstances, it is often unclear whether this practice falls within the technical definition of 'cattle feedlotting' contained in the *Environmental Protection Regulation 1998*. This type of operation is not generally regarded as a feedlot by the mainstream industry bodies and would not normally qualify for accreditation under the National Feedlot Accreditation Scheme (NFAS).

Limitations to Uptake

The main impediments to further adoption of best management practices are primarily related to economic issues. Periodic fluctuations in national and international beef markets, grain prices and climatic conditions over the past 20 years have resulted in 'boom and bust' cycles within the State's feedlot industry. While these fluctuations affect the whole industry, some of the larger, vertically integrated company feedlots often continue operating during times of industry downturn, whereas many small feedlots temporarily close down when economic conditions are not favourable.

Consequently, it is more difficult for small feedlot operators to justify expenditure on upgrading facilities that only operate intermittently, on an opportunistic basis. Economy of scale factors are also evident. For example, small feedlot operators are sometimes deterred from purchasing irrigation equipment suitable for irrigating effluent at sustainable rates, because they rarely accumulate sufficient effluent in their ponds to warrant the investment. Unless the feedlot operator has other irrigation supplies on the property, the irrigation equipment required for effluent irrigation is likely to be under-utilised.

Similar issues face small intermittent operators with regard to practices such as composting manure. Small operators do not generally produce sufficient manure to warrant undertaking labour intensive composting operations. In recent years, a composting contractor has commenced operating at some of the larger feedlots on the Darling Downs. Over time, a centralised composting operation may be developed in the Burnett-Mary catchment to receive manure from several feedlots. Alternately, the commercial composting operator based in Wondai who currently concentrates on piggery pond sludge may expand his business to cater for feedlot manure. The existence of such a facility may assist smaller operators by negating the need for on-site manure storage, processing and spreading.

The practice of drought feeding of stock in paddocks must also be addressed. Regardless of the legal status of this activity or recognition by industry, drought feeding constitutes a form

of intensive livestock production that can potentially have serious environmental impacts if facilities are inappropriately sited or poorly managed.

There are also likely to be a number of small feedlots, generally less than 50 head capacity, operating illegally on an intermittent basis within the catchment. These small feedlots were permitted to operate without any State government licences or approvals, prior to the amendment of the *Environmental Protection Regulation* in 1998. However, feedlots having capacities down to 1 head are now specified as ERA's that require an approval under the *Environmental Protection Act 1994*. The majority of these small operators are either unaware of the changes to the legislation requiring them to obtain an approval, or they choose to ignore this requirement, presumably because of their small scale and intermittent operation.

PIGGERIES

Distribution

Based on the Queensland pig herd distribution presented by Streeten and McGahan (2000) and Pig Stats (APL, 2003) data, it is estimated that there are approximately 200 piggeries in the region with a total capacity of approximately 200 000 standard pig units (SPU). (An SPU is a unit of measurement for describing the size of a piggery in terms of its waste generation. One SPU produces an amount of volatile solids equivalent to that produced by an average size grower pig of approximately 40 kg liveweight. Standard multipliers may be used to convert the number of pigs of different classes (e.g. boars, dry sows, lactating sows, suckers, gilts, weaners, growers and finishers) to the equivalent number of SPU).

From Table 2, it can be seen that the South Burnett is the most intensive pig production area in the catchment. There are also major piggery developments in the Monto, Mundubbera and Tiaro Shires. The 10 licensed piggeries listed in Table 3 each have capacities greater than 5000 SPU. These piggeries account for just over one third of the SPU in the catchment.

The DPI&F data outlined in Table 2 indicates the number and capacity of piggeries that are either licensed or approved under the *Environmental Protection Act 1994* or have development permits issued under the *Integrated Planning Act 1997*. This table does not include 'deemed approved' piggeries that had capacities less than 5000 SPU when the legislation was introduced in July 1996 and haven't changed hands or expanded in the interim. The operators of these piggeries were not required to submit an application when the legislation was introduced. Consequently, DPI&F does not currently have comprehensive data regarding these piggeries. However, there may be approximately 160 of these relatively small 'deemed approved' piggeries having a total capacity of 80 000 SPU in the catchment.

Traditionally, most piggeries were farrow-to-finish operations located at a single site. However, the industry is undergoing changes to traditional methods of pig production. Primarily for bio-security reasons, there is a trend to multi-site production with specific phases of the production system — breeding, weaning and growing — being located at different sites.

Most pigs are reared in conventional flushing sheds with partly or fully slatted floors to facilitate the collection and removal of excreta. However, the use of alternate housing structures, such as semi-permanent 'eco-shelters', is increasing for economic and welfare reasons. These shelters are most commonly used for weaner and grower pig accommodation, although, some Burnett producers favour the use of conventional flushing sheds for finishers. Eco-shelters are lower-cost, light (generally steel) framed shelters with synthetic fabric

covers, utilising straw or sawdust bedding (deep litter) to absorb the manure. Other absorbent bedding materials may also be used.

Within the Burnett Mary Region, there has also been limited interest in 'free-range' production and raising pigs in semi-confined outside areas over recent years. However, these production systems account for only a very small proportion of the industry in the basin.

Table 2. Number and capacities of licensed and approved piggeries.

Catchment	Shire	No of Piggeries	Capacity (SPU)
North Burnett	Eidsvold	1	1,300
	Monto	3	18,761
		4	20,061
Central Burnett	Gayndah	1	4,999
	Mundubbera	3	17,711
		4	22,710
South Burnett	Kilkivan	4	11,344
	Kingaroy	6	10,640
	Murgon	10	23,606
	Nanango	2	4,738
	Wondai	8	26,291
		30	76,619
Lower Burnett	Burnett	1	1,504
Burnett		**39**	**120,894**
Lower Mary	Tiaro	1	12,000
Burnett - Mary		**40**	**132,894**

Note: This table does not include a significant number of "deemed approved" piggeries that are not currently registered on the DPI&F database.

Table 3. Number of piggeries with capacities greater than 5000 SPU

Catchment	Shire	No of Piggeries	Capacity (SPU)
North Burnett	Monto	3	18,761
Central Burnett	Mundubbera	2	15,971
South Burnett	Murgon	2	10,400
South Burnett	Kingaroy	1	5,200
South Burnett	Wondai	1	5,000
Lower Mary	Tiaro	1	12,000
Total		**10**	**67,332**

Management Practices

Effluent from conventional sheds is generally treated and stored in earth ponds, prior to either recycling for shed flushing purposes or irrigation onto crop or pasture. Solids separation devices such as gravity run-down screens or screw presses are used at a small minority of piggeries to separate a significant proportion of the solids from the liquid effluent stream

before it enters the pond system. Used deep litter is removed from 'eco-shelters' after every batch of pigs. This mixture of manure and generally straw or sawdust is often partially composted on-site, before spreading onto cultivation.

A centralised commercial composting facility has been established at Wondai, in the South Burnett, to compost primarily piggery pond sludge. Pond sludge is transported from piggeries located mainly within the South Burnett for processing and bagging at this facility. This business has had some positive impacts on the region, effectively solving a problem for several small piggery operators who would not individually produce sufficient sludge to justify the equipment, labour and management costs required to establish on-farm composting facilities. This value adding business is also having significant economic and environmental benefits for the region, effectively recycling the valuable nutrient resources in the sludge into a valuable compost product that is readily usable as an organic fertiliser / soil amendment for agricultural, horticultural and domestic applications.

Limitations to Uptake

Similarly to the feedlot industry, economic factors are a major impediment to the implementation of environmental BMP's. The pig industry has had fluctuating economic fortunes over the past decade and is currently in the midst of a severe economic downturn. Consequently, many operators are reluctant to invest capital in upgrading facilities and improving practices that they don't perceive as having direct or immediate economic benefits.

Similarly to feedlots, economy of scale factors are also evident. For example, small piggery operators are sometimes deterred from purchasing irrigation equipment suitable for irrigating effluent at sustainable rates, because they rarely accumulate sufficient effluent in their ponds to warrant the investment. Because of it's high nutrient content, piggery effluent should generally be irrigated at relatively low rates over large areas. Unless the piggery operator has other irrigation water supplies on the property, the required effluent irrigation equipment is likely to be under-utilised. Furthermore, if no additional irrigation supplies are available, crop production will be limited by moisture stress in most seasons, limiting nutrient uptake and reducing sustainable effluent application rates.

Practical difficulties in desludging ponds and drying, processing and spreading the sludge also hinder the implementation of BMP's. Most piggeries do not have sufficient arable land area on site for the sustainable utilisation of sludge, screenings and used deep litter from 'eco-shelters'. Consequently, markets for the sale of much of this solid material need to be developed.

The commissioning of a centralised piggery sludge composting facility in the Burnett may assist producers in solving sludge disposal problems. With this type of facility, producers still have to desludge their ponds and dry the sludge on-site, however, they do not have to worry about processing or spreading the sludge on-site. Furthermore, the sludge is being value added to produce a readily marketable product and the nutrient value of the sludge is being enhanced and utilised.

The uptake of BMP's would increase if simpler methods could be developed to address some of the more difficult issues facing producers such as:

- ensuring that ponds are impermeable;
- pond desludging;
- sludge drying and processing and application to land;
- deep litter processing and spreading;

- soil monitoring;
- determining a program for sustainable effluent and solids application.

These issues highlight the need for effective, ongoing research and extension activities addressing these and other issues. Applying this research in the ongoing upgrading and development of industry guidelines and codes of practice, computer software and decision support tools will also assist the pig industry in improving the implementation of sound environmental management practices.

DAIRY

Distribution

It is estimated that there are currently approximately 256 dairy farms in the region milking a total of approximately 33 000 cows (Table 4). There has been rapid decline in the number of dairy farms since deregulation, in 1996 there 205 farms in the Mary catchment alone. The main dairy farming areas are the South Burnett and the Gympie districts. Queensland Dairy Accounting Scheme (QDAS) data (Busby *et al*, 2004) suggests that the average dairy farm in South East Queensland milks 140 cows with a total farm area of 186 ha, including 32 ha and 30 ha of winter and summer irrigation respectively. The irrigated areas generally consist of winter forage crops such as oats and ryegrass, and improved pasture and lucerne irrigated during summer. The average annual milk production is 5385 L/cow per lactation (17.6 $L.cow^{-1}.day^{-1}$), there has a consistent improvement in this figure (90/91-4200, 94/95 -5200 L/cow).

Table 4. Dairy farms in the Burnett Mary River region

(Source: QDO data).

Sub-catchment	Shire	Number of dairy farms	Sub-catchment Totals	Catchment Totals
North Burnett	Monto	15	15	
Central Burnett	Mundubbera	7		
	Gayndah	3		
	Biggenden	13	23	
South Burnett	Wondai	14		
	Kingaroy	9		
	Nanango	19		
	Murgon	14		
	Kilkivan (Part)	12	68	
Lower Burnett	Burnett	2		
	Kolan	2		
	Isis	1	5	111
Upper Mary	Caloundra	31		
	Maroochy	19	50	
Central Mary	Cooloola	81		
	Kilkivan (Part)	5	86	
Lower Mary	Woocoo	2		
	Tiaro	7	9	145
BMR Total				**256**

Management Practices

Dairy production systems in the Burnett-Mary catchment are highly variable. Some higher rainfall areas in the east, such as parts of the Gympie district, commonly utilise grazed pasture based production systems on the undulating terrain. By contrast, in the Burnett, many dairy farms rely on irrigated fodder crop production. However, across the whole region, most rely on a combination of grazed pasture and forage crops, and prepared rations fed to the cattle during milking and/or from a feed pad. Until very recently, there were also a small number of highly intensive dairies operating in the South Burnett, where all feed was fed to the milking cows on a feed pad and the cattle did not graze pasture or fodder crops.

Feedpads are another area of concentrated manure deposition. Feedpads are becoming more common following deregulation and the accompanying intensification of the industry. Cows may be confined to the feed pad area for periods from 1 to 4 hours per day. In some cases, artificial shade structures may be provided above the feedpad to ease heat stress during summer months. Cows may be held in this cooler environment for longer periods during summer.

Other concentrated manure deposition areas include:

- laneways used by cows in moving from the milking shed to grazed paddocks;
- loafing and camping areas where cattle often rest under trees or artificial shade;
- night paddocks where cows may be held overnight;
- areas surrounding watering facilities such as water troughs, dams and unfenced watercourses.

For the remainder of the day, dairy cows are likely to be grazing pasture and/or forage crops. Forage crop areas are a particularly important feed source during winter when pasture production is relatively low. Cows deposit manure widely across grazed paddocks.

Daily hosing and flushing water from the milking shed and yards and runoff from the yards is often directed to a solids trap where stones and larger suspended sediments are deposited. This often consists of a simple weld-mesh screen and/or a weeping drop-board weir constructed across a small concrete basin, where the solids are collected. Some farms may use more sophisticated solids separation devices such as stationary or vibrating run-down screens or screw presses. However, these more sophisticated devices would only be used on a very small minority of farms in the region.

Following solids separation the liquid effluent is generally directed to one of the following types of management systems:

- effluent collection sump;
- effluent treatment and storage pond system;
- direct gravity discharge to paddock.

Yards around the milking shed that are not flushed or hosed and the area surrounding any feedpad are generally dry scraped, on a regular basis, to remove deposited manure. The accumulated manure is stockpiled prior to being spread onto crop or pasture where it is used as a nutrient source and a soil amendment to improve structure and microbial activity. In some cases, the manure may be composted in wind rows before spreading. Manure stockpiles and composting facilities should be established on low permeability areas where runoff can be contained.

Limitations to Uptake

The main impediment to uptake of improved management practices with respect to NRM issues is the highly depressed economic conditions that the dairy industry currently faces. The combined effects of deregulation and the accompanying drop in milk prices on top of severe drought conditions and high feed commodity prices have severely affected the profitability of dairy farming. Producers are reluctant to spend any money on aspects of their operation that they do not perceive as bringing an immediate economic return.

While improved management of water, effluent and fertiliser can result in significant ongoing economic benefits, uptake of improved management practices may require targeted extension and education, in conjunction with incentive schemes such as RWUEI and the Mary Dairy Effluent Scheme.

POULTRY

Egg and meat chicken production in the region are both significant but not major industries, from a State or National perspective. DPI&F records are not necessarily completely accurate or up to date, but are likely to be the best data currently available. Based on DPI&F data, there are approximately 9 egg producers in the catchment with 76 000 laying birds (Table 5). From a State perspective, this represents 9% of the egg producers and 3% of the laying hens.

There are approximately 193 000 meat chickens in the catchment. This total includes 10 000 squabs (young pigeons) 5 000 ducks and 3 000 turkeys. A relatively large free range meat chicken facility has been established near Murgon. It is understood that this facility may be expanding in the relatively near future. Solid manure and litter is generally removed from intensive poultry sheds on a regular basis. After removal from the sheds, the manure and litter is often transported off-site immediately and spread on cultivation or pasture as an organic fertiliser.

In the case of free-range production, birds may be held in outdoor yards or ‘ranges’. In some cases, stocking rates may be too high for the survival of a vegetative ground cover. It is unknown whether any of the free range facilities collect runoff from the outdoor range areas.

Table 5. Egg and meat chicken producers in the region

Sub-catchment	Shire	Industry	No of Birds
North Burnett	Monto	Squab	5,000
Central Burnett	Gayndah	Squab	5,000
	Biggenden	Free range eggs	6,000
South Burnett	Kingaroy	Free range eggs	10,000
	Murgon	Free Range Meat Chicken	100,000
	Murgon	Meat Chicken	10,000
Lower Burnett	Bundaberg City	Eggs	10,000
	Kolan	Eggs	13,000
	Isis	Meat Chicken	5,000
Total Burnett:			**164,000**
Upper Mary	Noosa	Meat Chicken	25,000
	Maroochy	Eggs	10,000
Central Mary	Cooloola	Eggs	7,000
	Cooloola	Meat Chicken	25,000
	Cooloola	Turkey	3,000
	Kilkivan (Part)	Ducks	5,000
	Kilkivan (Part)	Meat Chicken	10,000
Lower Mary	Hervey Bay	Free range eggs	20,000
Total Mary:			**105,000**
Total Burnett - Mary:			**269,000**

APPENDIX IV

PRIORITY REGIONAL TERRESTRIAL WEEDS & THEIR MANAGEMENT

THE 10 PRIORITY WEED PLANTS – DESCRIPTION, WEEDINESS AND IMPACTS

Lantana (*Lantana camara*)
Lantana is a heavily branched, woody shrub that can grow as compact clumps, dense thickets and as a scrambling and climbing vine. Flowering occurs throughout most of the year with clustered compact heads about 2.5 cm in diameter. Colours vary from pale cream to yellow, white, pink, orange, red, lilac and purple. The ripe fruits are glossy, rounded, fleshy and purplish-black in colour.

Lantana is adapted to a wide range of habitats, from exposed dry hillslopes to wet heavily shaded gullies. It's ingress into native bushland increases soil fertility, encouraging further exotic weed invasions. Being a woody shrub, its presence helps create hotter bushfires. Seed is spread mostly by fruit eating birds, some animals and human activity. Germination rates are generally low and improved by seed passage through an animal gut. Plants need warm temperatures and sufficient moisture to establish. Lantana is native to the tropical and sub-tropical regions of Central and South America. There are four significant biological control agents established for this plant; *Teleonemia scrupulosa, Uroplata girardi, Octotoma scabripennis, Ophiomyia lantanae.*

The impact of lantana infestations on sustainable primary production is felt in grazing and forestry plantation enterprises. On grazing lands, it poisons stock, invades pastures and displaces desirable pasture species, increases the costs of mustering livestock, and increases property weed control costs. Lantana is listed as a Weed of National Significance in Australia. GRT is native to tropical and sub-tropical Africa. This plant has no known biological control agents in Australia.

Giant Rats Tail Grass *(Sporobolus pyramidalis* and *S. natalensis)*
GRT grass is a robust, tufted perennial grass growing up to 1.7 m tall. The seedheads can be up to 40 cm long and 3 cm wide, and develop an elongated pyramid shape when flowering. GRT can set seed throughout the frost-free period of the year and is capable of producing up to 85,000 seeds/sq m/year with initial seed viability of about 90%. A significant proportion of this seed can remain viable for up to 10 years.

GRT is aggressive, has low palatability when mature and is difficult to control. It can quickly dominate a pasture, especially following overgrazing, drought or soil disturbance. Mature leaf blades are tough and difficult for cattle to graze. The dry unpalatable GRT grass can become a serious fire hazard in the spring. GRT seed is spread by livestock (up to 30,000 viable seeds/beast/day) in manure and on fur and hooves, on vehicles and machinery (especially slashers and earth moving equipment), in hay and untested pasture seed, by fast flowing water and in turf or gravel. Maintaining strict property hygiene is important.

GRT infestations impact on sustainable primary production in grazing lands by reducing pasture carrying capacity and decreasing stock weight gains, increasing property weed control costs, and degrading the capital values of properties. Both species of GRT grass are declared Class 2 pest plants in Queensland.

Parthenium ***(Parthenium hysterophorus)***

Parthenium is an annual herb with a deep taproot and an erect stem that becomes woody with age. As it matures, the plant develops many branches in and may eventually reach a height of two metres. Leaves are pale green, deeply lobed and covered with fine soft hairs. Small creamy white flowers occur on the tips of the numerous stems. Parthenium normally germinates in early summer, produces flowers and seed throughout its life and dies around late autumn. However, plants can flower and set seed within 4 weeks of germination if stressed by seasonal conditions. It is a prolific seeder capable of producing up to 100 000 seeds/plant. Up to 340 million seeds/ha can be present in the surface soil compared to 120 000 native grass seeds.

Parthenium is a vigorous weed that colonises weak pastures with sparse groundcover. It will readily colonise disturbed, bare areas along roadsides and heavily stocked areas around cattle yards and watering points. It reduces the reliability of improved pasture establishment and reduces pasture production potential. It can cause serious allergic reactions in humans and animals, and can be poisonous to stock.

Parthenium seed is spread by livestock, in grain, seed and fodder, on vehicles and machinery (both farm and industrial), and in water. Maintaining strict property hygiene and vehicle/machinery washdown procedures is important. Parthenium is native to sub-tropical areas in South and North America. There are six significant biological control agents established on this plant; *Listronotus setosipennis, Smicroytx lutulentus, Epiblema strenuana, Zygogramma bicolorata, Bucculatrix parthenica, Puccinia abrupta var. partheniicola.*

The impact of parthenium infestations on sustainable primary production includes both grazing and field cropping farming systems. In grazing lands, it dominates pastures under continuous heavy stocking, excludes useful forage plants, decreases pasture productivity, carrying capacity and land value, and is a health hazard to landholders. In cropping land, it contaminates grain and other produce, and increases property weed control costs. This weed is a declared Class 2 pest plant in Queensland and is listed as a Weed of National Significance in Australia.

Mother of Millions ***(Bryophyllum spp)***

Mother of millions is an erect, smooth, fleshy succulent plant growing to 1 metre or more in height. They are escaped ornamental plants with five species commonly naturalised in Queensland and three of these spreading over substantial areas. All species form tall flower spikes in winter with clusters of bell shaped flowers. Each species has a distinctive leaf-shape, but all produce small plantlets along the edges of the leaves. These plantlets drop readily, develop roots, and establish quickly to form a new colony.

Mother of millions establish well in leaf litter or other debris on shallow soils in shady woodlands, and often grow on roadsides, along fence lines and around old rubbish dumps. They can spread from these areas, especially in flood, and establish if pastures are rundown. They are adapted to dry conditions and can survive long periods of drought.

These plants, and especially their flowers, are poisonous to stock and can cause a significant number of cattle deaths. When cattle are under stress from drought or in unusual conditions, they are more likely to eat strange plants. Since the plant flowers from May to October during the drier months of the year, the scarcity of feed may cause cattle to consume lethal amounts of mother of millions. Mother of millions is native to Madagascar. This plant has no known biological control agents in Australia.

The impact of mother of millions infestations on sustainable primary production in grazing lands is by the poisoning of stock especially in times of drought, and by increasing property weed control costs. It is a declared Class 2 pest plant in Queensland.

Groundsel bush *(Baccharis halimifolia)*
Groundsel bush is a densely branched shrub usually no more than 3 metres high. Male and female flowers are borne on separate plants. Pale yellow male flowers open from mid March, slightly earlier than the female flowers. The white female flowers are inconspicuous until seeds are fully developed with tufts of white hair, and begin to blow in the breeze from mid to late April. Two metre tall plants can produce up to 500 000 seeds. While most seeds fall within a few metres of the parent bush, wind updraughts can carry seeds many kilometres.

Groundsel is a rapidly growing weed capable of invading and dominating overgrazed pastures and other disturbed habitats, and is particularly suited to moist gullies, salt marsh areas and wetlands. It also grows well on high cleared slopes. It will proliferate rapidly from windborne seed, competing with pasture species for water and nutrients, and suppressing native plant communities.

Groundsel seeds are readily transported by wind, running water, vehicles and machinery. Soil disturbance in infested areas usually leads to substantial germination. Further infestation can occur unless the ground is sown to a competitive pasture. Groundsel is native to Florida and coastal areas adjacent to the eastern side of the Gulf of Mexico. There are six significant biological control agents permanently established on this plant; *Megacyllene mellyi, Oidaematophorus balantos, Rhopalomyia californica, Trirhabda baccharidis, Aristotelia ivae, Buccalatrix iveila, Puccinia evadens.*

The impact of groundsel infestations on sustainable primary production includes both grazing and forestry plantation enterprises. In grazing lands, replaces desirable pasture species, by increasing the mustering costs of livestock, and by increasing property weed control costs. This weed is a declared Class 2 pest plant in Queensland.

Fireweed *(Senecio madagascariensis)*
Fireweed is an annual or a short-lived perennial. It is a daisy-like herb that can vary greatly in size and shape depending on environmental conditions. In dry, harsh conditions it may be less than 20 cm tall with narrow leaves, no branching and few flowers. In ideal conditions fireweed can grow up to 50 cm tall with multiple branches, long wide leaves and about 100 flowers. The flowers are bright yellow, daisy-like with a diameter of about 2 cm and produce up to 100 seeds each. The seeds are light and have rows of very fine short hairs and a silky pappus (parachute) that enables them to be carried by the wind. An average plant can produce over 10,000 seeds during the season. It looks very similar to a range of native *Senecio* spp.

Fireweed is a weed of both arable country and rangelands. It can dominate pastures and is toxic to cattle and horses. Heavy infestations can result from the neglect of increasing infestations over several years, and the lack of good ground cover resulting from drought, overgrazing, fire or close slashing. Seeds germinate in mild, warm conditions in the presence of light and moisture. Most seedlings appear between March and June and then grow quickly to produce their first flowers in 6-10 weeks. A dry summer followed by autumn or winter rains leads to heavy infestations.

Fireweed seed is readily transported short distances by wind and stock. However, it is spread far greater distances in pasture seed, hay, turf, mulch and with stock transport. Fireweed is native to

Madagascar and southern Africa. While a number of biological organisms do attack fireweed, the effects are temporary and isolated.

The impact of fireweed infestations on sustainable primary production in grazing lands is by the poisoning of stock, reduced weight gains or low milk production, by the contamination of hay or silage, and by increasing property weed control costs. This weed is a declared Class 2 pest plant in Queensland.

Annual Ragweed *(Ambrosia artemisiifolia)*
Annual ragweed is an erect plant, 1 to 2 metres high with slightly rough fern-like leaves. Flowers are not conspicuous, small, greenish, and in spikes up to 20 cm long in the upper part of the plant. Flower spikes appear yellow when mature because of pollen production. Being an annual, the plant establishes each year from seed between spring and summer. Flowering occurs from mid to late March, after which the plants die. Late germinating plants may over-winter and survive until the next autumn.

Annual ragweed is a fast growing plant which can invade and suppress poorly managed pastures. Infestations can become very dense in overgrazed pastures and riparian zones. Although cattle will eat some annual ragweed, other pasture species will be grazed in preference. It often colonises bare areas on roadsides and banks of watercourses. This weed is potentially a serious human health hazard because it's pollen can cause respiratory allergies. Annual ragweed seed can be spread by floodwater, introduced by stock, be carried as a contaminant in fodder or topsoil, and on vehicles and farm machinery (especially slashers). Horses are often associated with the spread of this weed. Annual ragweed is native to eastern North America. While there are two established biological control agents which have reduced the size and vigour of the plant, the effects are limited.

The impact of annual ragweed infestations on sustainable primary production in grazing lands is by invading pastures and replacing desirable pasture species, by contamination of fodder, by increasing property weed control costs, and as a health hazard to landholders. This weed is a declared Class 2 pest plant in Queensland.

Cat's Claw Vine *(Macfadyena unguis-cati)*
Cats claw is a hooked climbing woody vine with an extensive thick root system including underground tubers. It has dark green trifoliate leaves (the terminal leaflet has a claw-like tendril), and bears bright yellow bell-shaped flowers in spring. It produces long narrow flattened seedpods in summer which release numerous seeds with a transparent papery wing to float on the breeze. Cats claw is predominantly a weed of timbered riparian zones and forestry plantations. This rampant vine can climb up and over trees to a height of 30 metres. The diameter of the stems (leads) can reach 15 cm, and there can be up to 30 leads per tree. It requires sunlight to flower. Heavy infestations will eventually kill riparian trees.

Cats claw seed is mainly spread over short distances by windborne seed. However, it is spread over greater distances by floodwater and stock. The seed can also be spread through hay, mulch, sand and gravel. Cats claw is native to Brazil and Argentina in South America. This plant has no known biological control agents in Australia.

The impact of cats claw vine infestations on grazing lands is by degrading the riparian zone vegetation which leads to declining water quality, by restricting the access of stock to water, by increasing property weed control costs, and by lowering the capital value of properties.

Prickly acacia *(Acacia nilotica)*
Prickly acacia is a thorny shrub or small tree growing 4-5 m high. The young shrubs form dense thickets, while mature trees are usually single stemmed with spreading branches that have lost most of their thorns. Pairs of thorns, usually 1-5 cm long, grow at the base of the leaves. Golden-yellow, ball-shaped flowers grow on stems from leaf joints with 2 to 6 flowers per group. Pods are 10-15 cm long, flat, with narrow constrictions between the seeds.

Prickly acacia was introduced into Queensland for shade and fodder early last century. Once established along bore drains and water courses, the trees spread out into adjacent pastures and form dense thickets. The pasture component decreases as the tree size increases because little grows under the canopy. Prickly acacia seed is mainly transported by stock as they feed on the leaves and pods. Mature trees along watercourses are the main seed producers, and a medium sized tree can produce 175,000 seeds per year. Seeds can remain viable in the soil for at least 7 years.

Prickly acacia is native to Pakistan. Certain native insects associated with Australian acacias attack this weed, and several additional biological control agents have also been released in recent decades; *Bruchidius sahlbergi, Homicloda barkeri, Chiasmia inconspicua and C. assimilis.*

The impact of prickly acacia infestations on sustainable primary production in grazing lands is by interfering with mustering and stock access to water, the replacement of pasture species, by facilitating soil erosion, and by increasing property weed control costs. This weed is a declared Class 2 pest plant in Queensland, and is listed as a Weed of National Significance in Australia.

Rubber vine *(Cryptostegia grandiflora)*
Rubber vine is a vigorous climbing vine with twining whip-like shoots which can grow unsupported as a shrub or can scramble up to 30 m high in trees. The flowers are large and showy with white to purple petals arranged in a funnel shape. The seedpods grow in pairs and contain up to 450 brown seeds. Each seed has a tuft of long white silky hairs, which enable dispersal by wind and water.

Rubber vine is mainly a weed of riparian zones and waterways where the seeds germinate in moist silt layers after rain. The plant smothers riparian vegetation and forms dense, sometimes impenetrable thickets. Infestations can spread outwards to invade pastures. The plant is poisonous to stock though seldom eaten except in drought. Rubber vine seed is most commonly spread by wind and running water. Creeks and gullies should be regularly inspected where prevailing winds may blow the seed from neighbouring infested areas, or where infestations occur upstream. Rubber vine is a native to Madagascar. There are 2 biological control agents successfully established on this plant; *Euclasta whalleyi, Maravalia cryptostegiae.*

The impact of rubber vine infestations impact on grazing lands by preventing access of stock to water and harbouring feral animals, by increasing the difficulty of mustering, by poisoning of stock, by the invasion of pastures, and by increasing property weed control costs. This weed is a declared Class 2 pest plant in Queensland, and is listed as a Weed of National Significance in Australia.

Table 1 assesses the extent and importance of weed species in the Burnett-Mary region in terms of the:

- current area of land infested;
- potential for further spread/thickening; and

- current impact on sustainable primary production.

Table 1. Priority weeds in the region.

Priority weed species (alphabetical order)	**Current area of land infested in the region** (descending order)	**Potential for further spread and/or thickening** (descending order)	**Current impact on primary production** (descending order)
Annual Ragweed (class 2)	1. Lantana spp	1.Giant rats tail grass (a)	1. Lantana spp
Cats claw vine (class 3)	2. Giant rats tail grass	2. Cats claw vine (b)	2. Giant rats tail grass
Fireweed (class 2)	3. Groundsel	3. Lantana spp (c)	3. Parthenium
Giant rats tail grass (class 2)	4. Cats claw vine	4. Parthenium (d)	4. Groundsel
Groundsel bush (class 2)	5. Parthenium	5. Fireweed	5. Mother of millions
Lantana spp (class 3) (incl. creeping lantana)	6. Mother of Millions	6. Annual Ragweed	6. Annual Ragweed
Mother of Millions (class 2)	7. Annual Ragweed	7. Groundsel (b)	7. Rubber vine
Parthenium (class 2)	8.African lovegrass	8. Mother of Millions	8. Prickly acacia
Prickly acacia (class 2)	9.Rubber vine	9. African lovegrass	9. Fireweed
Rubber vine (class 2)	10. Prickly acacia	10. Rubber vine	9. Cats claw vine
	11.Fireweed	11. Prickly acacia	

REGIONAL WEED INFORMATION SOURCES

- State of the Region Study version 3 (2004). This BMRG document does not contain any information on the status of terrestrial pest plants in the region.

- Mary River Catchment Strategy (1997). This MRCCC document sets out proposed weed management strategies and priority actions in Strategy LMP: 'Improving land management practices and fostering sustainable production', and in Strategy WNE: 'Enhancing the natural environment and wildlife'. However, it does not include specific information on the status of individual weed plants in the catchment.

- Mary River Catchment Strategic Directions (2002). This MRCCC document reviewed and refocussed the original 1997 strategies. Strategy 5.3 sets out the framework for the adoption of key weed management practices and priority actions, but does not include specific information on the status of individual weed plants in the catchment.

- Burnett Catchment Strategy (2000). Pest plants are recognised as a significant land management issue in the Burnett catchment, impacting on both sustainable primary industry and the biodiversity of ecosystems. The major' declared' weed species listed are giant rats tail grass, mother of millions, fireweed, parthenium, rubber vine, annual ragweed and groundsel. The major 'non-declared'weed species listed are creeping lantana, lantana, blue heliotrope, cat's claw vine, madeira vine, hymenachne and para grass.

- Baffle Creek Catchment Strategy (2001). This document includes an assessment on the economic, environmental and social threat of Declared plants and Environmental weeds to the catchment. The major species of Declared and Environmental terrestrial weeds are listed. Declared weed plants: giant rats tail grass, parthenium , groundsel bush, rubber vine, mother of millions, noogoora burr, milkweed, honey locust, annual ragweed and prickly pear. Environmental weeds: african lovegrass, balloon vine, blue heliotrope, broad-leaved pepper tree, camphor laurel, cat's claw vine, chinese celtis, climbing asparagus, creeping lantana, easter cassia, lantana, leucaena, mother of millions, resurrection plant, Singapore daisy, tecoma, thunbergia and wait-a-while.

- Weed Identification Booklet – Mary River Catchment (1995). This Gympie Landcare information booklet prioritises and illustrates the major terrestrial weeds in the catchment. The major species listed are giant rats tail grass, annual ragweed, parthenium, fireweed, mother of millions, lantana, noogoora burr, thistle spp, mistflower, groundsel bush, camphor laurel, chinese celtis, broad-leaved pepper tree, bitou bush, cockspur thorn, rubber vine, cat's claw vine and madeira vine.

- Assessment of Invasive Naturalised Plants in south-east Queensland (2002)
- This Plant Protection Quarterly paper lists 200 invasive weed species occurring in SEQ. The species were ranked on invasiveness and frequency in non-agricultural areas and/or remnant natural areas. One third of the 200 species listed were categorized as highly invasive. The 10 highest ranked invasive terrestrial species (in descending order) were lantana, groundsel bush, mother of millions, cats claw vine, madeira vine, ornamental asparagus, chinese celtis, camphor laurel, broad-leaf pepper tree and bitou bush.

- Weeds of Southern Queensland: a multi-criteria analysis supporting research priorities (2002). A draft document. This NRM&E study was undertaken to support informed decision making and planning on the requirements for future weed research programs in southern Qld. The criteria selected to evaluate the weeds were divided into two groups, namely the impact of the weed and the need for further research into controlling and managing the weed. The impact criteria were evaluated for both current and potential impacts. For each criteria, a weed was evaluated on the basis of the economic, environmental and social/cultural aspects. The priority terrestrial weeds for future research in southeast Queensland were ranked as follows: 1. Bamboo 2. African lovegrass 3. Asparagus-basket 4. Asparagus-climbing 5. Blue heliotrope 6. Lippia 7. Wait-a-while 8. Coral tree 9. Creeping lantana 10. Lantana.

Environmental Pest Plants in Riparian Zones

- Mary River & tributaries Rehabilitation Plan (2001). This MRCCC document includes a riparian environmental weed status assessment of 7 clusters of sub-catchment reaches (Priority 1='protected' to Priority 7='little chance of natural recovery'). The major species listed (and mapped) as impacting on aquatic ecology were: camphor laurel, privet, cat's claw vine, madeira vine and lantana.
- Conserving & Rehabilitating Mary River Cod Habitat (1998). This MRCCC document includes a status assessment of 300 km of riparian condition which ranks environmental weeds on a 4 point scale and by reach location. The major weed species listed (and mapped) as dominating riparian vegetation were: cat's claw vine, madeira vine, balloon vine, narrow-leaf privet, broad-leaf privet, chinese celtis, and camphor laurel.

THE LAND PROTECTION ACT (2002) AND DECLARED PEST PLANTS

Of more than 80 weed species declared Queensland-wide under the Land Protection (Pest and Stock Route Management) Act 2002 (Qld), approximately 30 occur in the Burnett-Mary region. These declared pest plants are targeted for control under state legislation, and have, or could have, serious economic, environmental or social impacts. Pest management legislation aims to help protect Queensland's economy, sustainable farming systems, biodiversity and people's lifestyles by:

- preventing the introduction and establishment of new pest plants in Qld;
- preventing the spread of established pest plants into new areas;
- and reducing the extent of existing infestations where feasible.

The declared weed plants are classed into 3 categories:

Class 1 weeds are not commonly present in Qld but if introduced, would cause an adverse economic, environmental or social impact. If present, they are subject to eradication. Two class 1 terrestrial weeds occur in this region; *alligator weed and honey locust*.

Class 2 weeds are established in Qld and have, or could have, an adverse economic, environmental or social impact. Landholders must take reasonable steps to keep land free of class 2 weeds. Seventeen of these class 2 terrestrial weeds occur in this region: *African boxthorn, American rat's tail grass, annual ragweed, fireweed, giant Parramatta grass, giant rat's tail grass, groundsel bush, harrisia cactus, hymenachne, mesquites, mother of millions, parkinsonia, Parramatta grass, parthenium, prickly acacia, prickly pear and rubber vine.*

Class 3 weeds are established in Qld and have, or could have, an adverse economic, environmental or social impact. A pest control notice can only be issued for land that is, or is adjacent to, an environmentally sensitive area. Thus the impact of species in this class is primarily environmental. Seventeen of these class 3 terrestrial weeds occur in this region; *African fountain grass, African tulip tree, Dutchman's pipe, asparagus fern, balloon vine, blackberry, broad-leaved pepper tree, camphor laurel, captain cook tree, cat's claw vine, Chinese celtis, lantana spp, madeira vine, privets, purple rubber vine, Singapore daisy and yellow bells.*

There are a number of weed species of local significance that have been declared by individual Local Authorities in the region for their own Council areas under their Council's Subordinate Local Law (SLL). Twenty-two of the 26 LAs in the region have declared one or more weed plants under their SLL. These include: *paterson's curse, clockweed, veined verbena, green cestrum, lippia, firethorn, bellvine, capeweed, African lovegrass, grader grass and creeping lantana*. Other SLL declared weed species that are now declared Class 2 weeds under the Land Protection Act 2002 include *giant rats tail grass and mother of millions*; and now declared Class 3 weeds - *privet, blackberry, lantana spp and African fountain grass*. The new LP Act 2002 would overrule these latter SSL declarations.

There are also some other priority weed species in the region that have not been declared for various reasons eg that they are considered to have already spread to their ecological limits. These weeds include; *bahia grass, African lovegrass, grader grass, thatch grass, blue heliotrope, wild tobacco tree, crofton weed, mistflower and blue morning glory.* Under the Land Protection Act 2002, every landholder has a statutory obligation to control declared plant pests and limit their further spread, be it on state, private or community lands. Local Government

Authorities have been charged with having Pest Management Plans in place and operational by 1 July 2004. These Shire Pest Plans list the priority Declared weed plants and the priority Environmental weed plants for each Council area. All 26 Local Authorities/Councils in the Burnett-Mary NRM region have individual Pest Management Plans.

THE NATIONAL WEED STRATEGY (NWS) 1999

The NWS takes a strategic approach to weed management problems of national significance, addressing environmental and agricultural weeds equally. The strategy describes the nature of the weed problem, outlines why existing weed management measures are not adequate, lists the roles and responsibilities of government, community, landowners and land users. It lists 3 goals with underpinning objectives and strategies:

- to prevent the development of new weed problems;
- to reduce the impact of existing weed problems of national significance;
- to provide the framework and capacity for ongoing management of weed problems of national significance

There are 20 weed species listed in the NWS as Weeds of National Significance (WONS). Nine of these WONS terrestrial weeds occur in this region; *alligator weed, blackberry, hymenachne, lantana, mesquite, parkinsonia, parthenium weed, prickly acacia and rubber vine.* Of these 9 weed species, only *lantana* and *parthenium* are currently regarded as major weeds in the region. However, the NWS eco-climatic modelling maps indicate the potential for all these 9 species to become major weed plants in the region, plus the addition of *bridal creeper* as a new weed species.
Fact Sheets are available on the National Weed Strategy–WONS website showing current and potential distribution maps for each of the above 9 terrestrial weeds in the region which have a WONS listing.

QUEENSLAND WEED HYGIENE DECLARATIONS (2003)

The most effective technique in the management of weeds is prevention and early intervention. This is a principle in the National Weed Strategy 1999. Until recently, most weed management resources have focused on controlling and containing established weed outbreaks, with little attention given to preventing weed spread and early intervention. One of the most cost-effective ways to control weeds is to prevent their spread. An important tool in preventing spread is the Weed Hygiene Declaration system introduced in 2003.

The Declaration was developed in response to landholders, rural industry, community and government desire to minimise the impact of weeds on business and the environment. It can be used for any Class 2 or 3 declared weed, undeclared weeds, and contaminated products. It provides information on whether any product is contaminated or free of weeds. The receiver can make informed decisions and take precautions to prevent new infestations.

The Declaration has also been designed to meet the legislative requirements of a ‘written notice’ under the new land protection legislation, Land Protection (Pest and stock Route Management) Act 2002 (Qld). A written notice is required prior to selling, giving, or supplying any ‘thing’, (eg machinery, stock, fodder, soil, water, gravel, grain, and vehicles) which may contain the Class 2 weeds listed below or their reproductive material. If a written notice is not given, a penalty of up to $30 000 can apply.

The following Class 2 pest plants are prescribed for section 45(1)(b) of the Act. These weeds are readily able to infest a wide range of products, from livestock to grain to vehicles. They have a major impact on pasture production and have the capacity to invade large areas of Queensland. They are *Giant rats tail grass, Giant Parramatta grass, American rats tail grass, Parramatta grass, Parthenium and Prickly acacia.*

Table 2. Biological control responses to priority regional weeds. Note: # this information may be dated

Priority weed species potential for further spread &/or thickening	Current biological control agents	Effectiveness of current biological control agents	Potential for future/expanded biological control
1.Giant rats tail grass	nil	n/a	???
2. Cats claw vine	nil	n/a	???
3. Lantana camara	* sap sucking bug, * leaf mining beetles (2) *seed feeding fly	Moderate?	Several new insect spp and a rust disease are being assessed #
4. Parthenium	* stem boring weevil * seed feeding weevil * stem galling moth * leaf feeding beetle * leaf mining moth * rust	Moderate?	Released but not yet established; # * Stem galling weevil * Root-feeding clearwing moth
5. Fireweed	* blue stem borer moth * orange rust	Poor?	No new agents for release in the near future #
6. Annual Ragweed	* leaf-eating beetle * stem-galling moth	Poor?	???
7. Groundsel	* stem borer * plume moth * gall-fly *leaf beetle * leaf skeletoniser * leaf miner * rust	Moderate?	A new rust fungus is now established on several sites #
8. Mother of Millions	nil	n/a	???
9. Creeping lantana	nil	n/a	???
10. Rubber vine	* moth * rust	Moderate?	???
11. Prickly acacia	* several native insects * seed feeding beetle * leaf feeding beetle * leaf feeding caterpillars (2)	Moderate?	Research into new agents is continuing in south Africa #

REGIONAL 'BEST BET" WEED MANAGEMENT IMPLEMENTATION RESPONSES
(excluding biological control options)

Invasive exotic weeds such as giant rats tail grass and parthenium have infested and dominated large areas of Queensland's sown pastures and native grasslands in recent decades. These invasions can no longer be regarded as one-off events as was originally considered to be the case following the early 1900s experience with the common prickly pear. The area of land infested with each of these terrestrial weeds now exceeds that of the previous prickly pear infestations.

<u>Lantana</u>
Lantana has probably already reached its potential ecological range of spread in this region. Therefore the priority should be on reducing the further ingress and thickening of lantana into grazing land. Dense vigorous pastures provide effective competition to limit the establishment of new lantana plants. Individual plants should be controlled before forming thickets.

* Priority Response 1: to target single plants on land accessible to machinery by slashing or grubbing, and follow-up with herbicide treatment on the new regrowth.

Giant rats tail grass

It is said that there are only two types of landholders in SEQ; those who currently have GRT infestations, and those who are going to get it! The main difference with the latter group is that while their properties are being constantly challenged by the relatively uncontrolled spread of GRT seed, they are successfully eradicating the initial 'scout' plants before seeding in the first year, thus preventing the insidious build up of an enormous soil seedbank (up to 20 million seeds/ha) on their properties. Managing pasture land to keep it in good health will minimise the opportunities for weed invasion.

* Priority Response 1: to reduce the risk of weed seed spread by educating the rural community to adopt the Weed Hygiene Declaration system which covers the sale or transport of potential weed contaminated things.
*Priority Response 2: to scout grazing land for new seedling plants and eradicate them by hand grubbing and bagging the plants for removal from the paddock.
* Priority Response 3: to extend a package of 'best grazing land management practices' to landholders to address the problems of poor pasture plant cover and decreased soil mulch cover which currently occurs during the annual winter-spring dry season and in the regular periods of drought that characterise our climate.
* Priority Response 4: to quarantine stock for 5 days before moving them to 'clean' paddocks or transporting them off the property.
* Priority Response 5: to promote the implementation of GRT-free buffer strips along boundary fence lines and waterways to restrict the spread of GRT seed from infested properties to clean properties (LAs have the authority to enforce buffer strips).

Groundsel bush

Groundsel has probably already reached its potential ecological range of spread in this region. Dense competitive pastures provide effective competition to limit the establishment of new groundsel plants.

* Priority Response 1: to scout grazing land for new seedling plants and eradicate by hand pulling or herbicide spot-spraying.
* Priority Response 2: to extend a package of 'best grazing land management practices' to landholders.

Cats Claw vine

Cats claw infestations in riparian zones and other forested areas continue to spread and thicken at an alarming rate in the region.

* Priority Response 1: to target and eradicate the early 'scout' plant infestations in the upper sub-catchments to prevent its establishment and further spread downstream by seed.
* Priority Response 2: early intervention to prevent new infestations from becoming established and forming dense thickets

Parthenium weed

Parthenium seed continues to spread and establish on properties which are feeding grain meal to livestock (incl poultry). It readily colonises weak pastures with sparse groundcover, bare areas along roadsides, and heavily stocked areas around cattle yards and watering points. Owners of

clean properties should ensure that vehicles and machinery from infested districts do not enter their properties without adequate washdown precautions.

* Priority Response 1: to promote the principle of instantly eradicating the initial ‘scout’ plants before they set seed, thus preventing the eventual build-up of enormous soil seedbanks (up to 340 million seeds/ha).
* Priority Response 2: to maintain strict property hygiene and vehicle/machinery washdown procedures.
* Priority Response 3: to reduce the risk of weed seed spread by adopting the Weed Hygiene Declaration system.
* Priority Response 4: to extend a package of ‘best grazing land management practices’ to landholders.

Mother of Millions
The priority should be in reducing the further spread of this weed in the region.

* Priority Response 1: to ensure that scattered infestations and small dumping areas on properties and roadsides are regularly checked and cleaned up.
* Priority Response 2: to promote the hand pulling and bagging up of isolated plants to prevent the establishment of new infestations.

Annual Ragweed
The priority should be in reducing the further spread of this weed in the region. Grazing management is also important; overgrazing will result in the loss of groundcover and a population explosion of this weed. Dense vigorous pastures provide effective competition to limit the establishment of new plants.

* Priority Response 1: to control new infestations when small, and not allow the weeds to establish and set seed.
* Priority Response 2: to extend a package of ‘best grazing land management practices’ to landholders

Rubber vine
The priority is to restrict or prevent seed coming onto ‘clean’ paddocks in the region. This is difficult to achieve if there are infestations upstream or on neighbouring properties, because the seed is spread by wind and running water. NRM&E ‘sweep’ teams have successfully targeted new outbreaks in the Burnett catchment.

* Priority Response 1: to target and eradicate the early ‘scout’ plants in the upper sub-catchments to prevent further spread downstream by seed.
* Priority Response 2: early intervention to prevent new infestations from becoming established and forming dense thickets.

Prickly acacia
The priority is to eliminate all plants along watercourses, dams and bore drains, because these trees produce seed in most years. NRM&E ‘sweep’ teams have successfully targeted new outbreaks in the Burnett catchment.

* Priority Response 1: to reduce further seed production by targeting infestations along watercourses etc.

* Priority Response 2: to restrict stock from grazing areas where mature pods are available by using strategic fencing
* Priority Response 3: to quarantine stock for 6 days before moving them to ‘clean’ paddocks.

Fireweed

Fireweed infestations are well established to the south of this region, and seed invasions by wind, machinery and various agricultural products is a continuing problem. It is only due to the diligence to date of Agency and Shire weed inspectors and landholders that these new infestations have been located and eliminated before seed has blown further north.

* Priority Response 1: to generate a greater awareness of the identification of this weed in the broader community
* Priority Response 2: to reinforce the current ‘weed scouting’ activities of weed inspectors and landholders to locate new plants.

APPENDIX IV
RELATIONSHIP BETWEEN THREATS AND NEGATIVE CONSEQUENCES

Relationship between current production practices if poorly applied and increasing risk of negative consequences from natural hazards

NATURAL HAZARD	Clearing Practices	Drainage Practices	Cultivation Practices	Grazing Practises	Agricultural Chemical Practices	Intensive Livestock Practices	Irrigation Practices	Forestry Mangmnt Practices	Intensive Cropping Practices	Fire Regime
Loss of Native Vegetation – salinity and erosion	+++			+++				+++	+++	+++
Cleared Land Weed Hazard	+++			+++				+++	+++	--- +++
Dispersive Soils mobilisation	+++	+++	+++	+++					+++	
Potential Acid Sulfate Soil	+++ ----	+++							+++	
Soil Degradation - compaction			+++	+++		+++		+++	+++	
Steep Land Erosion and Land Slip	+++		+++			+++		+++		
Soils Prone to Acidification					+++	+++	+++		+++	
Riparian Zones- erosion /nutrients	+++			+++		+++				
Latent Saline Hazards – groundwater waterlogging	+++	- - -				+++	+++	+++		
Low nutrient Waterways and Coastal waters Susceptible to Contamination	+++	+++	+++	+++	+++	+++	+++	+++	+++	

+++ A positive relationship between Production Process and Natural Hazard resulting in depreciation of Natural Capital.
- - - A negative relationship between Production Process and Natural Hazard reduces the risk of the hazard to degrade land and soil processes

APPENDIX VI

PORTFOLIO OF DPI&F NRM PROJECTS IN SEQ - 2002

Capability	Current Project
Assessment of vegetation ecology	Understanding causes of change in vegetation structure, composition and cover, including grazing, fire and climate impacts
Controlling horizontal and vertical nutrient flows	Nutrient movement from different farming systems; Environmental management information and advice
	Sustainable land management under tree base systems projects focussing on nutrient mass balance
Determining economics of grazing management strategies	Economic modelling of intensive farming systems.
	Develop and apply methods for assessing financial implications of different management options
Development and application of sustainability indicators	Research to minimise soil fertility decline. Computer generated practical farming systems are utilised
	Research into nutrient (P) adsorption in soils.
Development of environmental codes of practice	Documenting current recommended practices to industry and updating as required.
Development of land condition monitoring tools	Development of environmental monitoring techniques which are both cost effective and efficient.
Development of land condition monitoring tools	Developing practical methods of assessing paddock land condition and linking this to management of grazing pressure
Development of sustainable grazing management systems	Environmental implications and management of intensive dairy systems
	Strategies for spelling and managing spatial and temporal variation in grazing pressure; strategies to encourage desirable plants; tools for assessing and managing long-term and short-term carrying capacity; climate and grazing impacts on pasture dynamics
	Development and delivery of seasonal climate forecasts and decision support tools
Development of sustainable waste management practices	Assess the viability of utilising biosolids as an input into the farming system
	Researching sustainable waste management practices and extending these practices to industry.
	Management of waste water for irrigation of plantations
Development of tree-based systems to manage water on-site	Sustainable land management under tree base systems projects focussing on water use
Efficient water use	Efficiency of irrigation systems Adoption of best management practice. Water efficiency of different forages and appropriate irrigation strategies
	Study water use efficiency of trees
	Management systems to minimise off-site impacts and to maintain and improve water use efficiency. Monitoring practices to measure water use efficiency.
Forest health surveillance and monitoring	Forest health surveillance - softwoods & hardwoods
Integrated pest management	Research into development integrated management techniques for the control of pest to reduce chemical impact on the environment
	Develop and demonstrate strategies for reducing weed invasion and population build-up in grazing lands
	Development of pest and disease management systems in horticulture which integrate all production elements and solutions, to reduce reliance on chemical control measures and enhance market acceptance

Capability	Current Project
Integration of skills and disciplines	Risk management for crop, cropping systems, FS. Whole farm economic studies to identify key factors driving farm profitability, & also strategies to minimise financial risk associated with transition from current practices to new farming practices
	Development and delivery of seasonal climate forecasts and decision support tools
Landholder capability building	Collaborative work with grower groups throughout the region, examining issues associated with practical farm management (eg. tillage and traffic systems, fertiliser strategies etc.).
	NRM best management practices - Water, Nutrients
	Workshops proving information and tools for grazing land management; participative R&D; follow-up extension support
	Development and delivery of seasonal climate forecasts and decision support tools
Management of grazed woodlands	Understanding changes in woodland structure & composition; developing appropriate fire regimes
Minimising erosion and sedimentation	Minimal Tillage techniques
Monitoring and interpreting changes in land condition	Quantification of the productivity and profitability implications of various rotation breaks. Quantification of the deep drainage component of the water balance and the resulting down slope salinity implications associated with contrasting cropping system
	Regular monitoring of rangeland sites to assess condition, trend and structural change
Reducing pesticides in the environment	Development and application of chemical use systems to minimise off farm impacts. Utilisation of up to date pest management techniques to reduce chemical input
	Tick control using biopesticides. Environmental management information and advice
	Evaluation of biological pesticides for horticultural crops, implementing fungicide resistance strategies, evaluation of improved pesticide application equipment.
Seasonal forecasting of yield	Development and delivery of seasonal climate forecasts and decision support tools; SF of yield
Services and tools to rehabilitate degraded lands	Quantification of the deep drainage component of the water balance and the resulting down slope salinity implications associated with contrasting cropping systems ie. direct drill/opportunity cropping, v's conventional tillage/fixed rotations.
Services and tools to rehabilitate degraded lands	Development of hardwood tree taxa suitable for production in marginal landscapes and for environmental amelioration
Soil health management	Study performance of tree species in mixtures as opposed monocultures - soil health is a major component of the project. Soil pathogen studies.
Targeted training	Develop & apply methods to assess financial implications of different management options. Specific environmental workshops, field days & training events outlining sustainable management practices. Water Use efficiency. Apply NRM best management practices

APPENDIX VII

LANDSCAPE SCALE PARTICIPATORY ADAPTIVE MANAGEMENT PROCESSES

Neighbourhood Catchment Program

The Neighbourhood Catchment program aims is to improve land management practices to benefit everyone in the catchment. The program involves building capacity, in conjunction with regional Natural Resource Management groups, through communicating research knowledge, information, confidence and skills to meet specific targets.

The approach comprises two parts: A "Focus" Neighbourhood Catchment run by NRM&E that collects scientific data to determine the most effective land management and a "Community" Neighbourhood Catchment run by a Regional Natural Resource Management Group. The Community Neighbourhood Catchment brings landholders together with a vision to improve and measure sustainability at scales larger than the farm boundary.

The model is being successfully implemented in the Fitzroy Basin.

Integrated Area Wide Management Program

The integrated area wide management program has been successful in addressing a number of natural resource management issues in Emerald is an emerging model of a collaborative approach to natural resource management. This model is based on a self-regulatory approach by a local area management group collating and distributing data and providing support to growers to identify cause and effect that gives impetus to on-ground actions by growers to achieve solutions. This arrangement allows the group to work in tandem with peak industry bodies, government agencies and service providers to make continuous improvements towards NRM goals. Commonwealth and state funding has been obtained to run the program in the Queensland Murray Darling Basin under the banner of the Queensland Farmers Federation.

(Source : DI&F working papers on the options for the Agricultural Performance System)

Attributes of Good Landscape Scale Adaptive Management Programs

- Driven by a "community of interest", "sense of place" and a whole of landscape focus;
- Combine property and landscape scale information;
- Focussed catchment monitoring identifying link between cause and effect, not driving action from regionalised generalisations;
- Support to industry for regional initiatives and individuals through the creation of a "safe" learning environment;
- Build on and expand existing networks;
- Have a business and 'whole of systems' focus to achieve integrated environmental/ economic outcomes;
- Provide seamless delivery for regional NRM, and Industry Best Management Practice programs through genuine partnerships
- Allows resource managers on the ground to understand the issues, own the solution and develop cooperatively practical cost-effective solutions that make good business sense;

- Champions better use of available resources at the actual point where change is needed;
- Facilitates local person on the land to provide input into the setting of regional targets and their achievement;
- Trust and confidentiality established within the group to allow problems to be discussed openly and information to be shared externally by consent / agreement.
- Coordinates cross industry information sharing
- Provides access to property managers to spatial information regarding resources and trends on their property and builds databases/ GIS systems at a landscape scale from individual contributions.
- Develops capacity of landholders to interpret environmental data and environmental indicators in the environment.
- Enables real-time management of a problem was monitoring networks are established
- Provides value to the landholder to be involved through provision of meaningful information and technical support.

APPENDIX VIII

KNOWLEDGE AND INFORMATION GAPS

Forestry

- The health status of remnant and riparian vegetation in the Burnett and Mary River catchments. Comprehensive data on factors associated with rural dieback and current health status of remnant and riparian vegetation is needed for the region.
- Sustainable forest management practice. Comprehensive data are required on management methods, economic and environmental outcomes of private forestry practice in the region. Issues to be identified relate to the long term management of ecosystem integrity across forests, remnant and riparian vegetation in the region.
- Environmental impacts of fire and grazing management and fire risk assessment in private forests.
- The impacts of native forest and plantation management on soil and water processes such as water quality and yield effects of private native forestry and private and state managed plantations.

Grazing

- Further research into the continued diversification of income streams (forestry & grazing)
- Development of understanding of groundwater hydrological controls
- Need for demonstrated best practice (case study properties / sub-catchments)
- Full economic modelling
- Integration of alternative land use systems

Horticulture

Water Quality

- Further research on the effectiveness of control traffic, vegetation/trash cover in interows, minimum/zero tillage, buffer zones etc on the quality of water leaving farms and on water use.
- Impact of run-off from plastic mulch.
- What is a marketable yield? That is, researching the optimum water needs of crops to achieve the 'current' market requirements (sacrificing quantity of production over the desired size/quality to obtain highest market prices and demands).
- Improving the cost/benefit ratio of effective water use comparative to other key productivity/profit factors.

Pesticides and chemicals: Further work is necessary on:

- soil productivity system options which reduce pesticide use; the effectiveness of wind breaks; effectiveness, benefits, size and configuration of Riparian zones in Horticulture.
- Cost-effective and eco-friendly alternatives to Plastic Mulch which reduce the need for in-organic materials and chemical/fumigant use.
- Monitoring of sub-regional run-off to set benchmarks and to ascertain the effectiveness of new systems targeting reduced chemical use.
- Cost Benefit tools such as that developed for Rural Water Use Efficiency in the horticulture industry.
- Incentives and further promotion of Environmental Management Systems (eg. Banana) and QFF Farm Management Systems

Soil Health:

- The use of ameliorants to increase organic matter in soils (better soil health and water holding capacity).
- Preventing and reversing soil compaction, and understanding the impacts of soil compaction on productivity (particularly in tree crops).
- Impact of plastic mulch/fumigants and other current farming systems on soil health and productivity.

Waste Management:

- Cost-effective and eco-friendly alternatives to Plastic Mulch.

Biodiversity –

- Control and management of Flying Foxes and Birds in an economic and environmental manner (cost of netting etc. is too high, some current strategies seen as not being environmentally acceptable).
