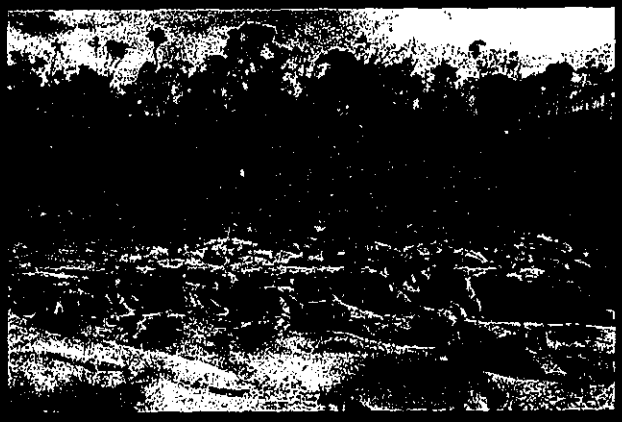

The North Australia Program

Catchment Management, Water Quality & Nutrient Flows as They Relate to the Northern Beef Industry

Scoping Study to Identify Appropriate Catchments for NAP3-Funded Research

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Preface

Meat and Livestock Australia acknowledges the excellent work of Christian Roth and his colleagues who conducted this scoping study. Using a previous literature review completed for the Meat Research Corporation (MRC) and the Land & Water Resources R&D Corporation (LWRRDC) as a starting point, Christian and his collaborating authors from agencies across northern Australia have brought together a rich diversity of literature, technical and industry expertise to provide recommendations for future work on catchment management, water quality and nutrient flows in the northern grazing lands.

The report provides a substantial basis for commissioning a multi-disciplinary study to quantify catchment-scale grazing impacts on sediment and nutrient exports in northern Australia.

This initial scoping work was commissioned in December 1997 and this report was submitted to the MRC in April 1998. It was jointly funded by the then Meat Research Corporation and the Land and Water Resources Research and Development Corporation, under Phase 3 of the MRC's North Australia Program.

Meat and Livestock Australia and the authors thank all those, both individuals and organisations, who generously contributed their time and information to this review.

Judy Lambert
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October 1998

0. Executive summary

Following a review of current information on the effects of grazing management in grazed lands of Northern Australia on water and nutrient cycles and the downstream fluxes of water, sediment and nutrients (Hook, 1997), NAP3 commissioned the present scoping study to:

- collate and review existing information on research projects studying water quality and nutrient flow issues as related to grazing management in Northern Australia and identify priority issues in need of new or further research within the context of the recommendations provided by Hook's review;
- assess the relative potential vulnerability of grazed catchments across Northern Australia and evaluate perceived risks to water quality and nutrient flows as related to soil types, current stocking pressures/grazing management practices and other land uses;
- provide NAP3 with recommendations on potential focus catchments for research into grazing effects on catchment response and optimum implementation through a major multi-agency research group.

On the basis of the review of ongoing research and monitoring and in view of the current work on off-site impacts and the limitations on funding, we recommend that future work on catchment management, water quality and nutrient flows as related to the northern beef industry be primarily focussed on:

- impacts of grazing management on sediment generation and nutrient loss at scales ranging from hillslope to catchment,
- quantification of key determinants of sediment, nutrient and overland flow processes at paddock, catchment and landform scales and their modeling to enable extrapolation to other catchments in Northern Australia.

Considering the complexity, longevity and costs associated with the establishment of a major project to conduct research into grazing management impacts on sediment and nutrient export, we recommend that:

- the project be focussed around critical research components addressing the above two sets of priority issues
- the research components be complemented by an effective communication strategy
- that the research components be designed so as to maximise links to existing research, particularly in the fields of off-site impacts and research into the socio-economic determinants of grazing management,
- the project be managed through a steering committee in liaison with a project coordinator responsible for research and communication coordination,
- the overall project be spread beyond the time frame of NAP3 and future funding sought.

Utilising a GIS analysis to assess intrinsic vulnerability and relevance of the catchments to the beef industry for all 132 catchments in NA, five potential catchments were shortlisted (Burdekin, Burnett, Fitzroy, Ord, Victoria). Following an expert ranking against a set of predetermined criteria, we make the following recommendations:

- *to select either the Burdekin or the Fitzroy catchment as the focus catchment for future research of grazing impacts on sediment and nutrient loss*
- *to select the Victoria catchment as a future case study catchment to apply and test the extrapolation of tools developed in the focus catchment study and to assess their utility for other grazed catchments in NA.*

1. Introduction

1.1 Rationale for study

Extended dry seasons in recent years combined with changed cattle production systems have placed increased pressure on native pastures across Northern Australia (NA). The resultant increase in grazing pressure has coincided with a growing awareness that activities in one part of a catchment not only affect land condition and processes where they occur, but that the changed processes on land can also lead to changes in waterways and downstream waterbodies. There is growing concern that high grazing pressures and inappropriate management of grazing land have resulted in increased flows of sediment and nutrient through and out of grazed catchments. Apart from the detrimental effects of nutrient and water loss on pasture productivity, there is particular concern that the off-site effects may impart negative impacts on water quality in rivers, health of in-stream ecosystems, on productivity of estuarine breeding grounds of commercial fisheries and on the ecology of off-shore reefs.

There is also increasing awareness of the need for Australian industries to be productive but not at the expense of degrading our natural resources so as to impair their capacity for use, including use by future generations. This need has been enunciated in the principles of ecologically sustainable development and the production of "clean and green" agricultural products. Bringing together the knowledge of scientists, primary producers and others who use and manage the different catchment resources, will play an important role in ensuring that the development of the beef industry takes place within the bounds of the productive potential and will take into account the susceptibility to deterioration of our land and water resources.

These issues are of concern to Meat and Livestock Australia (MLA) and the Land and Water Resources Research and Development Corporation (LWRRDC) and are being addressed in Phase 3 of the North Australia Program (NAP3). Phase 3 follows Phases 1 and 2, and extends from mid 1996 to mid 2001. NAP3, which is jointly funded by the MLA and the LWRRDC, seeks to "improve the profitability, international competitiveness and ecological sustainability of beef production in northern Australia". This is to be achieved through the operation of four sub-programs:

1. Meeting Market Requirements;
2. Improving Resource Management;
3. Improving Property Management; and
4. Improving Program Delivery.

Subprogram 2, Improving Resource Management, aims to increase international competitiveness and hence profitability, by improving the development and adoption of ecologically sustainable resource management systems and their profitable utilisation by the northern Australian beef industry. The key issues to be addressed by the subprogram are:

- the need to understand and more effectively apply existing principles and indicators of ecologically sustainable grazing systems;
- the need to continue and expand core investigations of the effects of grazing management strategies and to integrate them with activities promoting preferred strategies;
- the need to strategically position the northern Australian beef production sector to identify and deal with environmental threats and opportunities, including consideration of alternative resource management systems, should existing systems not be ecologically sustainable and profitable.

In this context, NAP3 commissioned a broad overview of current information on the effects of grazing management in grazed lands of Northern Australia, on water and nutrient cycles and the downstream fluxes of water, sediment and nutrients. An emphasis was laid on assessing interactions between grazing management (primarily stocking rates and their variation in time and space), drought and pasture improvement, as well as evaluating existing knowledge on impacts on riverine, estuarine and marine ecosystems. The outcomes of this review were published in a report by Hook (1997). The main recommendations emanating from this study are listed below:

1. Further information on current projects

Current projects related to water and nutrient movement, and catchment management more generally, need to be assessed to identify more specifically the knowledge that is being obtained and any deficiencies of the work. This will require the collection of further details on the problems being addressed, project objectives, methods being used, where the work is being undertaken, the organization that is doing it, the timescale and the sources of funding. NAP2 projects that are being extended into NAP3 need to be included.

2. Identification of appropriate catchment(s) for research

Given that major research will need to be limited to one or two catchments as a result of funding constraints, an important issue is the catchment(s) in which the research should be done. A scoping study that considers all catchments across northern Australia needs to be undertaken as a matter of priority. As a starting point, the study needs to establish the criteria against which catchments would be ranked and grouped. Some of the suggested criteria are:

- a perceived high potential for the grazing industry to affect land and water quality;
- a catchment community that wants the sort of information that will be generated by the research;
- a catchment that is considered to be important from the point of view of the grazing industry; and
- an effective extension process already in place to pick up research results and incorporate them into catchment planning.

The first criterion requires characterisation of catchments in terms of biophysical attributes, including geomorphology, climate and land use, in an attempt to identify potential vulnerability to degradation and risk of off-site effects. Also important are whether catchments are coastal or inland and whether rivers are regulated or unregulated. It is also recommended that this scoping project assess the land system and other resource mapping information available across northern Australia. Note should also be made of catchments in which NAP3 projects arising from NAP2 projects, are being undertaken.

3. Recommended research

The third recommendation is to establish a project or projects to identify management practices that cause significant effects and measure the effects that the north Australian beef industry is having on the movement of water and nutrients within the catchment and the effect of this movement on water quality and the sustainable use of other resources.

It is recommended that the research involve:

- an analysis of the surface hydrology, landforms and patterns of sediment generation, transport and deposition, and the delineation of geomorphic provinces;
- an interpretation of the inherent capacity of the geomorphic provinces to supply sediment and nutrients to the major river systems and the susceptibility of the land within them to degradational processes as a result of specific grazing practices;
- establishing budgets for water and key nutrients at paddock to catchment scales, using the provinces as a guide to major landscapes for which budgets are required;

- examining the extent to which grazing and grazing management practices enhance loss (as distinct from redistribution) of water, sediment, nutrient or organic matter, from local areas (ie, catchment divide to water course); and
- determining the effect any such losses are having on land functioning and productivity, both on and off site.

It was recognized that this project needs to be linked with the biodiversity research that will be funded in NAP3.

1.2 General approach

Based on the above recommendations made by Hook (1997) and taking into account the Terms of Reference stipulated for the present scoping study by the funding agencies (for detailed TORs refer to Appendix 8.1), the broad objectives of the study were seen to be:

1. collate and review existing information on research projects studying water quality and nutrient flow issues as related to grazing management in Northern Australia and identify priority issues in need of new or further research within the context of the recommendations provided by Hook's review;
2. assess the relative potential vulnerability of grazed catchments across Northern Australia and evaluate perceived risks to water quality and nutrient flows as related to soil types, current stocking pressures/grazing management practices and other land uses;
3. provide NAP3 with recommendations on potential focus catchments for research into grazing effects on catchment response and optimum implementation through a major multi-agency research group.

Given the time and resource constraints, the decision was made to progress the study through a combination of concurrent activities carried out by the core team members and a series of workshops involving experts selected from a broader reference group (for list of core members and reference group refer to Appendix 8.2). The first workshop, held at the commencement of the study on the 8th December 1997 in Canberra had the objective:

"of identifying and discussing criteria and information sources and of developing a conceptual framework that will provide the guidelines for assessing catchments in Northern Australia with respect to catchment management, water quality and nutrient flows as they relate to the northern beef industry".

A short report on the main workshop outcomes is provided in Appendix 8.3. The workshop established the methodological approach and identified suitable assessment criteria for the catchment ranking procedure chosen. It also focussed the scope of the study by prioritising the general issues of nutrient and water flows in grazed catchments. It ranked transport and loss of sediments and nutrients at hillslope to catchment scales as the overriding sustainability issue faced by the beef industry across Northern Australia (NA). Consequently, the remaining flow processes and degradation issues (groundwater pollution and/or extraction; dryland salinity, leaching and soil acidification) were not considered in the remainder of the study, either because of the lesser perceived relevance, or because these issues were already being addressed through other projects of NAP3 (soil acidification) or other programs (National Dryland Salinity Program).

Furthermore, in accordance with the Terms of Reference, it was agreed to restrict the study to the assessment of *grazing management* impacts on water and nutrient flows. Consequently, issues such as new water infrastructure projects and related water quantity assessments were

excluded from this study, in particular information related to the ongoing Water Infrastructure Development initiative being undertaken by Queensland.

The second workshop (for details refer to Appendix 8.3), held on the 17th March in Indooroopilly (Brisbane) was convened towards the end of the study with the intention of:

"bringing together the core team of the scoping study with experts in the reference group and industry stakeholders to present and discuss the results achieved with respect to the selection of potential focus catchments, the research priorities identified and a conceptual framework to address the research issues".

It essentially endorsed the catchment prioritisation approach taken and the resultant shortlisted catchments, as well as firming up the research priorities, and the conceptual research and communication framework. It also enabled the study team to obtain valuable additional feedback for inclusion into this report.

2. Identification of research priorities

2.1 Inventory, documentation and analysis of current projects

Further documentation of current research projects to provide a clearer understanding of existing investigations relevant to water quality and nutrient flows was a recommendation that arose from Hook's report (1997). Consequently, an objective of this study has been to collate and review existing information on current research projects studying water quality and nutrient flow issues related to grazing management in Northern Australia. In some cases this included revisiting some of the projects listed by Hook (1997), but a large number of additional research and monitoring projects were also assessed here. A further objective has been to identify priority issues within the context of the recommendations provided in the review by Hook (1997) and in particular, to assess the collated research information to determine whether any of the priority issues identified in Hook (1997) are already being covered.

The study core team identified the various research institutions and agencies likely to be funding/ carrying out relevant research and nominated different individuals from within the core team to be responsible for obtaining information from these bodies. Three categories of information were to be sought: information on research projects, information on monitoring and information on any existing data sets, such as water quality data, climate data, and so on. To ensure the information obtained was similar for all projects and covered the key items of interest, standard proformas were drawn up to cover each information category. These were sent to relevant staff within the various institutions and agencies, either to fill in directly and/or to pass on to others within the organization.

As a starting point in identifying relevant people to contact, contacts were listed that had been consulted in the previous review by Hook (1997). Those who had already provided complete details of past research/monitoring projects and who were not a point of contact for further projects were not given proformas. In addition to people on this list, contact was also made with project leaders who were involved with relevant current research projects being funded by the Land and Water Resources Research and Development Corporation (identified from their most recent research compendium). Also, core team members identified further contacts due to their own knowledge of the organizations for which they had been assigned responsibility. A complete list of agencies and staff contacted is provided in Appendix 8.2.

As well as these sources of information, several commonwealth government agencies and programs were identified as sponsoring projects which could provide useful data or projects about which any major catchment research within northern Australia should be aware. Agencies and programs known to be relevant or about which further information was sought are given in Table 2.1.

The emphasis in this study was to obtain information on projects associated with sediment and nutrient generation and movement as they relate to the grazing industry. Proformas also have been returned for projects that are relevant to catchment research within NAP3 but which are outside research associated with sediment and nutrient movement. The research and monitoring projects and data sources have been listed according to their broad area of relevance. This listing of projects is given in Tables 2.2 - 2.6; complete research proformas are given in Appendix 8.4.

Table 2.1: Commonwealth government agencies and programs about which information was obtained, and persons contacted.

Agency and Branch	Program and contact	Relevant projects
Special advisory council responsible to the Minister for Primary Industries and Energy	The National Land and Water Resources Audit - Janice Oliver (project officer)	Defining methods and incorporating appropriate indicators for the National Land & Water Audit - personnel commissioned to identify possible methods
Bureau of Resource Sciences (BRS) - Agricultural Production and Natural Resources	Sustainable land and water resource management - Michele Barson	Monitoring Land Cover Change
	Innovative and sustainable agricultural systems (WWW site)	
	Dynamic land resource inventory and analysis systems (WWW site)	
National Resource Information	National and regional resource management systems - Bob Munro	• Cape York Peninsula Land Use Study - Ian McNaught • Gulf of Carpentaria multiple land use data audit • Digital information data base
Department of the Environment	National Wetlands Program (Alison Shepard)	Listing of relevant projects (see Table 2.4)
Department of the Environment and LWRRDC	The National Wetlands R&D Program (WWW site)	Listing of relevant projects (see Table 2.4)
	National River Health Program (WWW site, Peter Davies)	Monitoring River Health Initiative (WWW site and NT representatives)
Department of the Environment and Department of Primary Industries and Energy	National Heritage Trust (Annemarie Watt)	Listing of community based programs in short-listed catchments (see Table 2.7)

A total of 41 research, 16 monitoring and 8 data source proformas were returned. Of the research proformas, 4 were not considered relevant to the scope of this study and were discarded. The research and monitoring proformas were then grouped into five topics:

1. projects relevant to sediment and nutrient flow processes in Northern Australian catchments
2. projects relevant to grazing management, land condition and pasture restoration
3. projects relevant to on-site effects of sediment and nutrient loss and to the effects of sediment and nutrient on marine, riparian and freshwater systems

4. projects relevant to the effects of climate variability on pasture growth and land condition
5. projects investigating land and water resources, their general condition and their management.

Note that in some cases, projects cover several topics and grouping had to be undertaken on the basis of perceived main focus. Research projects are numbered and complete proformas are listed in Appendix 8.4 in the same order as in Tab. 2.2 - 2.6.

Response rate varied. At the time of report compilation, return rate for projects in topics 1 (Tab. 2.2) and 2 (Tab. 2.3) was deemed reasonable and probably covered most of the major ongoing projects. With respect to assessing off-site impacts, we believe that some gaps still exist, as return rate from some institutions engaged in freshwater and marine ecology research related to sediment and nutrient imports was generally low. Regarding geographical distribution, it appears that the ongoing work in northern WA and the NT was fairly comprehensively covered, whilst coverage in QLD remains patchy as not all proformas were returned.

In evaluating the current research projects related to sediment and nutrient flow, it is evident that there continues to be a marked paucity of activity at larger scales, corroborating the findings of Hook (1997). The majority of projects summarised in Tab. 2.2 operate at plot to micro-catchment scales (0.1 - 100 ha), with only a very few projects looking at larger scales. In most cases (Nos. 4, 5, 6, 8 and 9 in Tab. 2.2) the work is only partially relevant to the measurement of grazing management impacts in NA, as these projects refer to catchments not very relevant to the beef industry (Herbert, Johnstone, QLD part of Murray-Darling Basin). There is virtually no ongoing catchment scale sediment and nutrient work in northern WA and the NT.

Table 2.2 Projects relevant to sediment and nutrient flow processes in Northern Australian catchments (details see Appendix 8.4).

Project title	**Project leader**	**Organisation responsible**	**Location of project**
Research			
1. Climate variability, grazing management and nutrient loss in a tropical savanna	Dr Peter O'Reagain	Queensland Department of Primary Industries, Charters Towers	"Wambiana", south of Charters Towers (Burdekin Catchment)
2. Development of a three-dimensional facies model for variable-discharge, tropical rivers: the Upper Burdekin	Dr. C.R. Fielding	Dept. Earth Sciences Univ. Queensland, Brisbane	Burdekin River, upstream from Charters Towers
3. Erosion risk assessment of the TFTA/Dotswood	Dr Christian Roth	CSIRO Land and Water, Townsville	Section 7 of the Townsville Field Training Area, Dotswood (Burdekin)
4. Land management to reduce nutrient movement from catchments	Geoff Titmarsh, QDNR	Centre for Integrated Resource Management	Queensland part of the Murray-Darling Basin

5. Modelling sediment and nutrient sources and stores and the risk of their delivery through catchments	Dr Chris Moran	CSIRO Land and Water, Canberra	Section 7 of the Townsville Field Training Area, Dotswood (Burdekin Catchment)
6. Nutrient and sediment delivery from the Herbert River	Dr. Chris Barnes	CSIRO Land and Water, Canberra	Herbert River
7. Paddock scale guidelines for salinity management in the Balfes Creek Catchment	Ian Gordon	Queensland Department of Natural Resources	Balfes Creek Catchment near Charters Towers (Burdekin Catchment)
8. Sediment history of the Herbert river floodplain	Prof. Bob Wasson, Dr. Jon Olley	ANU, Canberra; CSIRO Land and Water, Canberra	Herbert River
9. Sources and delivery of suspended sediment and phosphorus to Australian rivers Part A: radionuclides and geomorphology	Peter Wallbrink and Cathy Wilson	CSIRO Land and Water, Canberra	Berner's Creek, North Johnstone River, Qld
Monitoring			
Groundwater level monitoring	Peter Jolly	NT Department of Lands, Planning and Environment	Major communities and towns in the NT
Stream flow monitoring	Peter Jolly	NT Department of Lands, Planning and Environment	Major rivers in the NT

Projects relevant to grazing management are far more numerous and fairly evenly distributed across NA (Tab. 2.3). In most cases the primary focus is on pasture stability (pasture species), managing introduced legumes, controlling woody weeds, pasture restoration and some aspects of biodiversity. The scale of the work is predominantly plot to paddock. Some measurements of runoff, sediment and nutrient loss are being carried out at this scale that may be valuable in understanding grazing management / soil erosion interactions at larger scales. Depending on the focus catchment/s selected and the location of some of the ongoing work within those at catchment/s there is scope for linkage and value-adding of the ongoing work. Another important feature of a number of the projects listed in Tab. 2.3 (Nos. 12, 17, 19, 20, 23) is the high degree of producer involvement. Experiences gained from these projects in terms of raising producer awareness for sustainability issues in general and soil erosion specifically and the prospects for enhanced channeling of research outcomes need to be carefully evaluated and drawn upon.

Another major initiative of importance in this context (not listed in Tab. 2.3; for more details see end of Appendix 8.4, p. 176) is the BEEFPLAN project currently being developed by MLA as a new major project within NAP3. This project follows a new concept, whereby producer groups engage in a "holistic" approach to property management by building on their abilities as enterprise managers operating within a complex system. The objective is to harness these capabilities in developing management systems that enable the appropriate application of a mix of new technologies and principles, information and opportunities to the business. It his hoped that this approach maximises benefits from existing R&D outcomes and understanding of sustainable land management.

Table 2.3: Projects relevant to grazing management, land condition and pasture restoration (for details refer to Appendix 8.4).

Project title	Project leader	Organisation responsible	Location of project
Research			
10. Biological and economic consequences of managing water-point distribution in rangelands	Craig James	CSIRO Division of Wildlife & Ecology	Barkly Tableland, NT
11. Determinants of land degradation in wet/dry tropical savannas	Garry Cook	CSIRO Division of Wildlife & Ecology, Darwin	Transect in northern Australia?
12. Developing sustainable grazing management systems for the semi-arid tropics of the Northern Territory	Rodd Dyer	NT Department of Primary Industries and Fisheries, Rockhampton	Victoria River District and Sturt Plateau
13. Effects of stocking rate, legume augmentation, supplements and fire on animal production and stability of native pastures	Dr Bill Burrows	Queensland Department of Primary Industries	"Galloway Plains", Calliope, Central Queensland (Fitzroy Catchment)
14. Enhancing pasture stability and profitability for producers in *Aristida/Bothriochloa* woodlands	Dr R.G. Silcock	Queensland Department of Primary Industries	Injune and Rubyvale (Fitzroy Catchment)
15. Environmental management of military lands in Tropical savannas	Dr. Andrew Ash	CSIRO Tropical Agriculture, Townsville	Townsville field training area; Keelbottom and Star Rivers, Upper Burdekin
16. Incorporation of practical measures to assist conservation of biodiversity within sustainable beef production	Dr Sue McIntyre	CSIRO Tropical Agriculture, St Lucia	Crows Nest, Auburn R. areas (Burnett Catchment)
17. Management of native pastures oversown with Stylo	Deryk Cooksley	QDPI, Mareeba	Field trial and Dimbulah and commercial properties
18. Managing tropical woodlands to control exotic woody weeds	Dr Tony Grice	CSIRO Tropical Agriculture, Townsville	Various sites in Burdekin River catchment; Balfes Creek sub-catchment
19. Managing woodlands: developing sustainable beef production systems in northern Australia	Dr Andrew Ash	CSIRO Tropical Agriculture, Townsville	Various sites in Burdekin River catchment; Cardigan, Hillgrove, Allan Hills/Lakeview
20. Mechanisms of pasture change and strategies for restoring the productivity of spear grass and *Aristida/Botriochloa* grasslands	Col Paton	Queensland Department of Primary Industries	Three sites in the Burnett River catchment; Glencoe, Derarby, Corrunovan

21. Rangeland monitoring, Victoria River District and indicators for sustainable land production and condition	Bob Karfs	NT Department of Lands, Planning and Environment, Palmerston	Victoria River District
22. Reclamation of degraded land in the Desert Uplands	Dr Mal Lorimer	Queensland Department of Environment	Desert Uplands biogeographic region (Burdekin, Fitzroy)
23. Sustainability of *Stylosanthes* based pasture systems in northern Australia: managing soil acidity	Dr Andrew Noble	CSIRO Land and Water, Townsville	Townsville, northern and central Queensland and the NT
24. Woodland management and woody weed control for Queenslands beef pastures	Dr Bill Burrows	Queensland Department of Primary Industries	Many sites throughout Queensland
Monitoring			
Determining the productive capability of your land to develop sustainable management practices	Shane Walsh	"Rossgae", Proston QLD	Various sites throughout Queensland
Mary River (NT) Integrated Catchment Management	Rod Applegate	NT Department of Lands, Planning and Environment	Various monitoring sites in the Mary River catchment
QGRAZE and GRASSCHECK	Eric Anderson	Queensland Department of Primary Industries	Approximately 400 sites throughout Queensland
Rangeland Monitoring - Barkly Tablelands	Frazer McGregor	NT Department of Lands, Planning and Environment	Barkly Tablelands
The Western Australian Rangeland Monitoring System (WARMS)	Andrew Craig	Agriculture Western Australia	Approximately 320 sites in 9 'pasture groupings' throughout the East and West Kimberly

If appropriately linked to research aimed at impacts of catchment management on water quality and nutrient flows in grazed NA catchments, there is a higher likelihood of some of the concepts of off-site impacts finding their way into producer decisions. The potential for grazing management impacts on sediment and nutrient export to be addressed within a grazing systems framework rather than on the basis of individual control measures makes the linkage to BEEFPLAN an avenue worth exploring in greater detail.

Only two projects were identified that either directly or indirectly address the on-site effects of sediment and nutrient loss on pasture productivity (Nos. 25, 29, Tab. 2.4). Considering the importance of nutrient and water loss for pasture productivity, this continues to be a major gap in actually providing sufficient quantitative information to enable the assessment of the relevance of on-site impacts. Various projects are ongoing regarding off-site impacts. Issues of impacts of sediments and nutrients into freshwater bodies are mainly being investigated in the Fitzroy (Nos. 26, 27, Tab. 2.4) and Burdekin (Nos. 30, 32) catchments. Marine impacts are being studied through a number of projects out of AIMS and through the CRC Reef Research, focussing on impacts on the Great Barrier Reef Lagoon along the east Queensland

coast, with a focus on the Fitzroy and Burdekin mouths (Nos. 28, 30, Tab. 2.4). In general, it would seem that specific projects to study off-site impacts need not be funded out of NAP3, but rather that the off-site impacts can be addressed by ensuring linkages are sought to the ongoing activities. In individual cases this may require some top-up funding to enable more direct links to be established.

Table 2.4: Projects relevant to on-site effects of sediment and nutrient loss and to the off-site effects of sediments and nutrients on marine, riparian and freshwater systems (for details refer to Appendix 8.4).

Project title	**Project leader**	**Organisation responsible**	**Location of project**
Research			
25. How long will soil resources last with current grazing practices?	Mark Silburn	Queensland Department of Natural Resources, Toowoomba	DNR South region, particularly Condamine, Maranoa and Balonne catchments
26. Impact of downstream effects of agricultural practices in the Fitzroy Catchment	Robert Noble	Queensland Dept. of Natural Resources, Bileola	Fitzroy catchment
27. Management strategies for the control of cyanobacterial blooms in the Fitzroy River barrage	Dr Myriam Bormans	CSIRO Land and Water	Fitzroy River, Rockhampton
28. Marine biogeochemistry and sedimentation history	Dr Greg Brunskill	AIMS	GBR lagoon, near the mouths of Herbert and Burdekin rivers
29. Nitrogen deficiencies in clay soils	Dr David Tongway	CSIRO Division of Wildlife and Ecology	Victoria River District, NT
30. Nutrient and sediment inputs to the GBR from north coastal QLD	Dr Miles Furnas	AIMS	Major rivers from Cape York to Fitzroy River
31. Riparian zone management – central Upper Burdekin catchment	Damian Burrows	JCU Tropical Freshwater Center Townsville	Burdekin catchment near Charters Towers
32. Stream processes and water quality at Townsville Field Training Area	Prof Richard Pearson	JCU Tropical Freshwater Center, Townsville	Townsville filed training area; Keelbottom and Star rivers, Upper Burdekin catchment
*Biological survey of the Arafura swamp			Arafura Swamp
*Identifying and monitoring change in wetland inundation patterns, Kakadu, NT	Assoc. Prof. A.K. Milne	University of New South Wales	Kakadu National Park
*Modeling ecological responses to water regimes in arid zone wetlands	J. Puckeridge	University of Adelaide	

*Sediment guidelines for managing and protecting aquatic ecosystems	Assoc. Prof. Bill Maher	CRC for Freshwater Ecology	
*The effect of flow on nutrients in wetland habitats	M. Thoms	University of Canberra	
*Weed management and the biodiversity and ecological processes of tropical wetlands	Michael Douglas	NT University	
Monitoring			
Mangrove monitoring network	Brad Comley	NT Department of Lands, Planning and Environment	Initially Darwin Harbour with the objective of extending to throughout the NT
Monitoring River Health - aquatic biota	Jane Suggit	NT Department of Lands, Planning and Environment	Major rivers of the Top End
Monitoring River Health - stream turbidity and bank erosion	Judy Faulks	NT Department of Lands, Planning and Environment	Major rivers of the NT

* Proformas were not requested for these projects

Effects of climate variability on pasture (grass) growth are being tackled through a major multi-agency program led by QDNR (Tab. 2.5). Whilst the principal focus has been on predicting biomass production on the basis of seasonal climate (rainfall) forecasting to assist the grazing industry in matching stock densities to safe carrying capacities, this project provides a major potential link to catchment hydrology through its ability to provide some of the relevant information required to predict overland flow and discharge. Conversely, it would seem that work aimed at quantifying grazing management impacts on water flows at larger scales would ultimately lead to the development or refinement of hydrological models, that if integrated into the AussieGRASS program, would enable the spatial assessment techniques currently being utilised to be improved, by moving away from point scale models to true catchment models. Therefore, it is important to recognise that future catchment scale work in NA needs to be well linked into this program.

Table 2.5: Projects relevant to the effects of climate variability on pasture growth and land condition (for details refer to Appendix 8.4).

Project title	**Project leader**	**Organisation responsible**	**Location of project**
Research			
33. Australian Grassland and Rangeland Assessment by Spatial Assessment (Aussie GRASS)	Ken Brook	Queensland Department of Natural Resources	Throughout rangelands of Qld, NT and WA

Various projects concerned with investigating land and water resources, their general condition and their management are listed in Tab. 2.6. An important project in terms of drawing upon experience in involving communities, local government and producers in issues related to resource management and sustainable use of land is the Central Highlands Regional Resource Use Planning Project (No. 34), that could open some important communication channels. The State of the Rivers project in QLD bears considerable potential for linking grazing management effects to health of riparian zones. However, at this stage, of the catchments studied none are relevant for the NA beef industry. The forthcoming reports on Cooper Creek and the planned Burnett study hold more promise in this respect.

Table 2.6: Projects investigating land and water resources, their general condition and their management (for details refer to Appendix 8.4).

Project title	**Project leader**	**Organisation responsible**	**Location of project**
Research			
34. Central highlands regional resource use planning project	Dr Allan Dale	CSIRO Tropical Agriculture, St Lucia	Shires of Bauhinia, Emerald, Peak Downs, Belyando and Jericho, Fitzroy and Burdekin catchments
35. Decision support systems for natural resource managment	Dr Daniel Walker	CSIRO Tropical Agriculture, Townsville	Herbert River catchment
36. Groundwater resources of Balfes Creek Catchment	Ian Gordon	Queensland Department of Natural Resources	Balfes Creek Catchment near Charters Towers (Burdekin Catchment)
37. State of the Rivers - An Ecological and Physical Assessment of Rivers and Streams in Queensland	Glen Moller	Queensland Department of Natural Resources	*Reports published for*: Maroochy, Upper Condamine, Dawson, Herbert and Mary Rivers and Lockyer Creek. *Draft reports for*: Bremer and Tully Rivers and Coopers Creek *Survey in progress for*: Border Rivers and Mooloolah River/Pumicestone passage catchments. *Proposals submitted for*: Burnett River
Monitoring			
Water resource assessment of the Barkly Tablelands, Victoria River District, Sturt Plateau and Arnhem land	Peter Jolly	NT Department of Lands, Planning and Environment	The Barkly Tablelands, Victoria River District, Sturt Plateau and Arnhem land

There are several funding programs within the Natural Heritage Trust - Bushcare: The National Vegetation Initiative, Endangered Species, Farm Forestry, Fisheries Action, Landcare, Rivercare, Waterwatch and Wetlands. Queensland is also covered by the Murray-Darling 2001 Program. Tab. 2.7 below shows the number of projects funded within the

different Natural Heritage Trust programs in the Northern Territory and Queensland. Projects for the north of Western Australia, the area that is relevant to the northern pastoral industry, have not been included in the Table as it is difficult to determine the locality of many projects from the data given. Also, no attempt has been made to determine the funding provided to each State/Territory or the total estimated cost of the projects. Given the multitude of projects, a more detailed breakdown of projects has been restricted to the sections covering the five potential focus catchments (6.4.1 to 6.4.5).

Table 2.7: Number of projects funded within the different Natural Heritage Trust programs in the Northern Territory and Queensland

Program	Northern Territory	Queensland
Bushcare	34	72
Endangered species		5
Farm forestry	1	5
Fisheries action	4	11
Landcare	73	220
Murray Darling 2001	N/A	35
Rivercare	5	23
Waterwatch	7	15
Wetlands	5	6

2.2 Identification and prioritisation of research issues

As the overview of ongoing research in the preceding section indicates, the principal knowledge gaps and research priorities with respect to catchment management, water quality and nutrient flows as they relate to the northern beef industry as identified and discussed by Hook (1997) in her review essentially remain unaddressed. The current level of research activity in North Australia continues to focus on plot to paddock grazing management issues. These in many cases are of more direct relevance to producers in enabling them to improve their land management with the immediate aim of maintaining or increasing enterprise profitability and, by doing so, eventually contributing to an increased ecological sustainability of grazing in NA. However, within the broader context of sustainability and the growing recognition by the grazing industry of the need to be seen to be producing beef without adversely impacting riparian zones critical for biodiversity, and affecting freshwater and marine ecosystems, the lack of research activities targeted at strengthening our understanding of catchment scale processes and off-site impacts poses serious risks for the future. This can be clearly illustrated by the following two examples of the very few existing comprehensive studies of grazing management impacts on catchment response.

In the first case, in the Nogoa catchment study conducted by Ciesiolka (1987), the key findings suggest that in some instances erosional effects of post-European settlement cannot be clearly discerned, because of the confounding effects of geomorphology and climate (in particular, single major events), although there was a clear tendency for decreased levels of cover increasing soil and water loss. More importantly, in badly eroded areas of the Nogoa catchment pasture restoration was not always successful, even after stock exclusion and revegetation measures were implemented.

In the Ord River study, which dealt with a far greater areal extent and which was initiated in the wake of observations of continued delivery of sediments to Lake Argyle from the Ord Regeneration Reserve (De Salis, 1993), there is a clear indication that excessive stocking pressure on some of the more inherently vulnerable parts of the catchment (eg Hardman Basin) has resulted in severe increases of erosional activity (Wasson *et al.*, 1994). These land systems with calcareous soils formed from Cambrian sediments were evidencing widespread sheet and gully erosion as a result of overgrazing, leading to major inputs of sediments to Lake Argyle. Even several decades after the establishment of the Ord River Regeneration Reserve, associated with a pronounced decrease in stock numbers (but not in feral grazing pressure) and with an extensive pasture restoration and revegetation program, there is evidence of continued high levels of gully erosion from activated gullies within the Reserve (De Salis, 1993; Novelly, 1994; Wasson *et al.*, 1994). Therefore, not only does this indicate that inadequate grazing management can lead to widespread degradation and loss of on-site productivity as well as increased off-site impacts, but far more seriously, once triggered, there are few if any economically feasible means of controlling severe gully erosion, resulting in a total loss of productive capacity.

Irrespective of the somewhat conflicting conclusions from both studies concerning the relevance of grazing, the high potential risk of long-term quasi irreversible negative impacts clearly underscores the necessity for further R&D investment into improving our knowledge base of catchment responses to grazing.

Having briefly reiterated the relevance of the broader issues, based on Hook's review (1997), the outcomes of the 2nd scoping study workshop and the preceding section, we can proceed to define the specific research issues by identifying three main subsets of issues related to:

1. hillslope and sub-catchment processes
2. catchment scale assessments
3. off-site impacts

In addition to these primarily biophysically oriented issues, this study also wishes to highlight a fourth major subset of research issues within the socio-economic realm, which was previously not covered by Hook (1997) as going beyond the scope of her review. The specific research issues within each of the four subsets are listed below:

Research issues subset 1 - hillslope to sub-catchment processes

- processes involved in change of and quantification of infiltrability for various land types under different grazing pressures, and the resulting characteristics of overland flow
- soil entrainment, deposition and redistribution processes to determine the extent to which grazing is causing *net* water, sediment and nutrient export from hillslopes above natural rates
- the impact of nutrient and water loss on pasture productivity, enterprise profitability and the functioning of the land type - vegetation - grazing system continuum
- spatial assessment of grazing land management techniques (i.e. stocking densities, spelling, fire management, fencing and waterpoint locations, tree clearing, pasture remediation) and their potential to reduce soil and water movement

Research issues subset 2 - catchment scale assessments

- understanding sediment and nutrient generation, transport through and export from large catchments as affected by grazing and in relation to different geomorphology, vegetation and climate:
  - time-frames involved
  - role of episodic events

- which erosional processes dominate and where
- changes in sediment size-classes

- developing modeling capabilities to determine sediment delivery ratios and hydrological response, based on a sound conceptualisation of the dominant processes that occur. These models need to use existing resource information and permit extrapolation to other catchments in Northern Australia
  - deriving functional geomorphological indicators
  - using combinations of digital terrain analysis with remotely sensed information
  - coupling to "real-time" assessment of land condition using remotely sensed indices of vegetation change
  - enabling the performance of risk assessments

Research issues subset 3 - off-site impacts

- impacts of grazing management on riparian zone vegetation and biodiversity, bank stability and direct sediment and nutrient inputs into rivers
- relationships between sediment and nutrient input to freshwater ecosystems (algal bloom dynamics, aquatic habitat and populations) and role of dams and ponded pastures as sinks
- impacts of sediment and nutrient export and freshwater surges on marine ecosystems
  - marine fish and prawn productivity
  - biodiversity and conservation
  - tourism values

Research issues subset 4 - socio-economic determinants of grazing management decisions

- factors determining producer awareness of ecological sustainability and soil erosion
- significance of "clean and green" image in marketing of beef products and in producer decision making
- effect of financial constraints on adoption of research outcomes
- defining on-site and off-site impacts in monetary terms and cost sharing of downstream effects between producers in a catchment
- social and technological changes in rural communities and their impact on land management decision making.

In terms of prioritisation and in the context of limited R&D funds, research within the first two subsets must be considered as a prerequisite to addressing the central theme of grazing management impacts on sediment and nutrient export, followed in order of importance by research aimed at issues listed in subsets 3 and 4, which would include highly desirable research to achieve a full understanding of implications beyond the direct grazing management - catchment response relationships.

2.3 Recommendations

In conclusion, we formulate the key question for sustainability facing the northern beef industry as being:

> "how does grazing management affect sediment and nutrient delivery at varying scales and what are the impacts (on and off site) of sediment and nutrient loss".

In view of the ongoing work on off-site impacts and the limitations on funding, we recommend that future work on catchment management, water quality and nutrient flows as they relate to the northern beef industry be primarily focussed on:

- impacts of grazing management (i.e. stocking densities, spelling, fire management, fencing and waterpoint locations, tree clearing, pasture remediation) on sediment generation and nutrient loss at scales ranging from hillslope to catchment,

- quantification of key determinants of sediment, nutrient and overland flow processes at various scales and their modeling to enable extrapolation to other catchments in Northern Australia.

3. Evaluation of resource information and other data sources

One recommendation arising from Hook's (1997) review was the need to better assess the availability and utility of land resource information, both in terms of underpinning any future research on catchment response to grazing impacts, as well as its adequacy to assist producer's decision making to improve land management. In this chapter, we provide a brief overview of existing resource information, its sources and its general relevance to producer decision making. Detailed compilations of resource information are provided specifically for the short-listed potential focus catchments in sections 6.4.1 to 6.4.5, as it was not deemed necessary and beyond the scope of this study to deliver an exhaustive listing for all of NA.

3.1 Overview and assessment of existing resource information

A great deal of land resource information exists for NA that is appropriate at sub-catchment to large catchment scales. These data exist in different forms. Some are available in map format, which depending on the period of the survey, may be available in digital format or only in hardcopy format, with or without accompanying reports or documentation. Various federal and sate agencies are custodians and providers of the data and in most cases information on data, its quality and its accessibility can be assessed through the Internet, with the following being some of the major sites:

- Geological surveys - AGSO; 1:250,000 digital maps of geology and a wide range of other products;
  http://www.agso.gov.au/front/products.html

- Land systems, land unit surveys - CSIRO; Land systems information mostly at 1:1,000,000 - 1:250,000 in hardcopy format for Kimberley, Victoria District NT, parts of Queensland; various surveys held by federal and state agencies:
  http://www.nric.gov.au/nric/data/ndar_overview.html
  http://www.nt.gov.au/dlpe/
  http://www.agric.wa.gov.au/
  http:www.dnr.qld.gov.au/

- Soil surveys - NRIC digital Atlas of Australian Soils, 1:5,000,000;
  http://www.nric.gov.au/nric/data/ndar_overview.html
  http://www.nric.gov.au/nric/data/nricdata/aussoils.html;
  various surveys held by State agencies:
  http://www.dnr.qld.gov.au/land/lris/lris/pages/mapsprod.html

- Vegetation and land condition surveys - the major source is the current SLATS project, for which QDNR is the lead agency:
  http://www.dnr.qld.gov.au/slats/index.html

- Pastureland and rangeland surveys - MRC/Tothill and Gillies map on pasture lands, 1:4,000,000; now available in digital format from Land Resource Assessment and Management, Brisbane

- Survey of important wetlands and information on biodiversity- ERIN; various products and maps;
  http://www.environment.gov.au/

- Climate data - Bureau of Metereology, various products;
  http://www.bom.gov.au/climate/
  http://www.dnr.qld.gov.au/longpdk/index.html

- Water resources and water quality data - main custodians of water resource information are the various state agencies:
  http://www.nt.gov.au/dlpe/
  http://www.wrc.wa.gov.au/waterinf/index.html
  http://www.dnr.qld.gov.au/water/water_reports/north/index.html

- Topographical and digital elevation data - AUSLIG; various products; digital topographic sheets; digital elevation models (18" and 9");
  http://www.auslig.gov.au/products/digidat/digindex.htm

Some other valuable sites with general information on resource and environmental data are:

http://www.nric.gov.au/nric/data/data.html
http://www.environment.gov.au:80/marine/mcdd/agency_lists.html
http://www.erin.gov.au/edd/owa/edd_search2.category_list

While geological, topographical, land tenure and land use information and digital elevation data is generally available at scales 1:250,000 for most of NA, extensive areas remain unmapped at scales suited to the management of the soils and land resources. Most of the land resource mapping so far has concentrated on coastal and more intensely settled areas with large portions of the central parts of each State not yet mapped. These tend to be the drier, less productive portions of northern Australia.

Other types of data that may pose restrictions to conducting catchment scale research in grazed catchments is the paucity of well gauged, continuously monitored discharge measurement and water sampling sites on the major river systems in NA. In recent years, there has been a strong downsizing of relevant activities in the State agencies charged with operating these sites. This is reflected in the fact that still a major portion of NA's catchments has not been fully gauged (AWRC, 1976). A further potential limitation is to be expected in the low density of rainfall gauges across NA. Any serious attempt at modeling of catchment hydrology will be greatly hampered by insufficient temporal and spatial resolution of rainfall data and climate data in general.

The land resource surveys that have been done vary in the scale of mapping, the data collected, and the methods used in data collection. Some organisations (such as in the Northern Territory) have concentrated on provision of essentially scientific, often process-orientated data that has a wide range of applications, and others (as in Queensland) have increasingly offered more specific, industry-orientated, and extension types of information.

Over all three States the scale of the mapped land resource data has often been quite small, especially the CSIRO surveys. Over any significant area, map scales have been largely in the range 1:500,000 to 1:2,000,000, which can only give a broad overview assessment of land capability for the beef industry and its environmental impacts. Only relatively small areas of rangeland have been mapped at more useful scales, such as 1:100,000 or 1:250,000. Significant areas such as coastal Queensland have been mapped at 1:50000 – 1:100000, with associated resource attribute information. A common complaint from the industry (eg. in Western Australia) has been that in land system surveys land units are only identified and

described, they are not located and delineated, so that in practice pastoralists cannot easily focus on areas of key importance as far as sediment and nutrient yield are concerned. In Queensland all areas mapped as land systems are available in digital format with associated descriptions and reports. Detailed site descriptions and analytical data is also available.

Northern Territory

The adequacy of land resource survey data and future needs have been assessed for the Northern Territory by Barson *et al.* (1997). She indicates that the Territory is covered by reconnaissance surveys undertaken at a scale smaller than or equal to 1:250,000 and that most of these give general descriptions of soils, and a few have some profile descriptions, so that little actual quantitative point source soil and vegetation data exists. The Top End of the Territory is better served. The majority of the survey work to date has established the general nature of the land resource and its broad suitability for the major forms of land use. However, the availability of information at a scale needed to identify specific land pastoral management requirements and to establish whether land use is sustainable is more limited. Much of the current coverage of land resource information is limited to the north and the south of the Territory; around the Top End and in the Alice Springs district. Coverage generally has been purposeful, systematic, and with a view to pre-empting demands from pastoral, mining, national park and aboriginal interests. Currently, work aimed at mapping land resources at a scale of 1:100,000 in the Victoria River district is nearing completion.

The Northern Australian Region Geographic Information System (NARGIS), soon to be transferred to the Science Faculty of the NTU, holds much of this information in digital format. NARGIS has conference proceedings with additional resource information dated 1993, 1995, and 1997.

Western Australia

Most attention in this State has been paid to the portion close to Perth, and the adjacent northern and western crop and mining lands. The CSIRO has in the past focussed on the Kimberley region with land systems reports and maps of the Ord-Victoria region, the North Kimberley, and the West Kimberley, but map scales have been very small, eg. 1:1,000,000 for the Ord-Victoria survey.

Land resource surveys in WA now tends to be needs driven. Recently the WA Dept. of Agriculture has worked in more detail in the West Kimberly area, and in the Pilbara. The as yet unfinished Pilbara survey is using the methodology of the former North Eastern Goldfields Study and is designed to be digital.

Queensland

In Queensland there has been a concerted programme of land resource surveys. The CSIRO has undertaken 5 significant surveys (the Mitchell-Normanby; Leichhardt Gilbert; Nogoa-Belyando; Isaac-Comet; and Dawson-Fitzroy areas). In addition, QDPI has undertaken a range of similar and also more detailed studies of the land with all semi-arid and arid areas and coastal areas mapped. The coverage is of different types, with land system surveys recently declining in favour of land resource surveys at 1:50000 – 1:25000 to meet industry and environmental requirements. Most of the major outputs are now in digital format and are listed on the Web, except for surveys in the Cape York Peninsula area and the Soil Fertility of the Central and North East Grazing Lands study.

3.2 Conclusions

The current resource information situation in NA presents a mixed picture. Some data forms are readily available and highly amenable to applications in catchment scale research (geology, digital elevation data, vegetation and land cover from satellite imagery). Other crucial land resource information, in particular soil maps and information on spatial distribution of relevant soil chemical and physical data is very patchy in some areas and of varying scale and quality because it has often been obtained utilising different survey methodologies.

One key implication is that any future tools to extrapolate from the focus catchment (and that presumably will possess an above average level of available land resource information) to other catchments across NA will have to be tailored to be able to utilise the more readily available data. This will pose some challenges to future research efforts, and some of the traditional hydrological modeling approaches may not be viable under these circumstances.

The other clear conclusion emanating from the brief evaluation in the preceding section is that with a very few exceptions of extensive areas in coastal and near coastal areas , there is virtually no soil information available at scales commensurate with scales at which producers tend to make decisions on land management (ie 1:50,000 for smaller properties to 1:100,000 for larger properties). Surveys are usually done for planning purposes, not property management. However soil and land resource information from surveys is very useful as a base for management, including as it does detailed site and analytical data. It is inconceivable that this situation will change in the short term, and certainly it cannot be addressed by relying on traditional forms of soil and land resource assessment to cover the vast extent of NA's grazing lands. Rather, it will be necessary to develop novel approaches to improve our capability of extracting larger scale information from existing land resource information, using combinations of tools based on enhanced satellite images coupled to digital terrain analysis and conceptual modeling from experienced resource surveyors and underpinned by strategic ground truthing. This, however, represents another research field in its own right and certainly would seem beyond the scope of NAP3.

4. Assessment of producer awareness and prospects for technology transfer

Despite continued high levels of investment into R&D to increase our knowledge of key land degradation processes and the effort put into development of more sustainable land management practices and the ongoing attempts at extending this knowledge to producers, issues such as soil erosion with the associated on-site and off-site implications continue to be a high on the agenda. This raises several questions. Foremost, what are the reasons behind the perceived reluctance to adopt more sustainable land management practices based on what we currently already know and what means do we have to overcome some of these barriers? Secondly, in the context of this study, how do we measure the potential for adoption of grazing management options designed to reduce loss of sediment and nutrients? These questions need to be addressed if any benefits expected from investment into new research on catchment management, water quality and nutrient flows as they relate to the northern beef industry are to be maximised and actual progress made on reducing adverse grazing impacts.

Consequently, the objectives of this chapter are two-fold:

- highlight some of the issues related to producer perceptions and reasons for non-adoption in order to assist in the design of an effective communication strategy as integral part of the research framework presented in the next chapter

- provide some indicators with which it is possible to assess the likelihood of increased producer endorsement and adoption and that would be suitable to be used in the evaluation of the potential focus catchments in section 6.4.

4.1 Communication of natural resource issues

It is well documented that in general Australian producers do endorse concepts of stewardship and conservation (e.g. Barr and Cary 1992; Vanclay and Lawrence 1995). Some producers do see conservation as having wider economic rewards and that land degradation will affect future production. Producers are also sufficiently concerned about the issue of land degradation to join local groups, discuss the issues and to lobby for funding (e.g. Campbell 1994; Vanclay and Lawrence 1995). However land deterioration remains a major issue. Despite favourable attitudes and known solutions, appropriate practices in many cases are not being adopted at the farm level (Vanclay and Lawrence 1995, ANAO 1997; IC 1997). This apparent contradiction has been attributed to a wide variety of social, economic, cultural, perceptual and situational reasons (e.g. Cocks 1992, Vanclay and Lawrence 1995). Some of these issues of relevance to the beef industry are discussed below.

Producer Perceptions
It is argued that it is highly unlikely that attempts to improve producers' attitudes will be key to increased adoption of sustainable environmental management practices (e.g. Cox *et al.*, 1995; Vanclay and Lawrence 1995). Furthermore, despite producer awareness of land degradation and conservation, the complexity of many natural resource issues means few land managers have adequate knowledge of environmental processes to develop well-informed opinions in relation to the situation of their own properties. This lack of knowledge may translate into lack of support for natural resource management policies in some instances, and also may be responsible for unfavourable attitudes and/or erroneous information about an issue that can have detrimental effects on decision-making (Lawrence and Vanclay 1995; Tarrant *et al.* 1997).

Vanclay and Lawrence (1995) identify one of the fundamental problems to be a misperception and underestimation of land degradation processes. While most producers perceive some problems in their district, few consider that their own farm is at risk from land degradation - the "not in my back-yard" or NIMBY syndrome (Commonwealth of Australia 1989; Vanclay and Lawrence 1995). Vanclay (1992a) has attributed producers' failure to recognise the early warning signs of land degradation to most media and extension presenting dramatic images of severe forms of land degradation. In part this failure may also be attributed to the difficulty in assessing the land's resilience and the long timescales for signs of land deterioration to appear. A critical factor in changing behaviour in respect of land and water management is therefore increasing producer's knowledge of land degradation processes and symptoms, in particular early warning signs of land degradation. Furthermore MacLeod and Taylor (1992; 1993) found widely differing perceptions amongst a broad range of stakeholders of grazing system of sustainability issues. Importantly, they found that researchers/technical specialist perceptions of the nature and scale of the problem was often very different to that of producers.

The implications of these findings are, firstly, there is a need is to address the spatial variability of the problem so that site specific implications of processes and hot-spots can be identified. Secondly it suggests the need for a partnership approach to RD&E to establish a negotiated process of exploring and owning the problem and exploring and negotiating the solution.

Reasons for non-adoption

The adoption of environmental management practices is fundamentally different from the adoption of commercial innovations in agriculture (Vanclay and Lawrence 1995). In the latter, producers make a choice about what is in their economic and social interests. In the former, the public may desire changes which the farmers reject or do not believe are their individual responsibility. Moreover, different short and long-term perspectives in adopting commercial or environmental practice also compounds adoption. Different signals will result in different behaviours (Vanclay and Lawrence 1995). Farmers' non-adoption of technology and of environmental management practices therefore may be rational, in keeping with the desire to minimise costs (e.g. Frank 1995a, 1995 b; Vanclay 1992b). Often non-adoption is for very pragmatic reasons, where the technology being promoted is not suited to the new environment or social context (Frank 1995a, 1995b). Vanclay and Lawrence (1995) identify a number of key consideration including:

1. Complexity: the more complex the innovation, the greater the resistance to adoption.
2. Divisibility: producers can adopt the part of the innovation that they like or is consistent with other farming objectives, and consequently, the more divisible an innovation, the more likely it is to be adopted.
3. Congruence: incompatibility with farm and personal objectives. Producers are more likely to adopt innovations which are compatible with other farm and personal objectives.
4. Loss of flexibility: with fluctuating market prices, producers are most likely to resist the adoption of new technology that restricts their flexibility.
5. Economics: because environmental innovations rarely provide direct economic benefit to the individual producer, especially in the short term, there would be very little adoption of environmental innovations if producers were to base their adoption decision solely on economic terms.
6. Implementation Cost-Capital Outlay: often adoption of new techniques may require the producer to forego income until the new approach is established. The capital required to adopt a new technology is an important consideration.
7. Implementation cost - intellectual outlay: producers may have to learn new ways of doing things. Many producers may not have had a good formal education, the motivation

or financial wherewithal to engage in further education, such that the mastering of a new technology may not be viewed by producers as worthwhile.

8. Risk and uncertainty: producers need to be sure that the conservation technology will actually provide the anticipated environmental benefits and outcomes.
9. Conflicting information: producers receive their information from a range of sources. Conflicting information in the external sources of information is one reason for non-adoption.
10. Environmental perception: producers are likely to adopt environmental management techniques when, among other things, they consider themselves to be personally at risk from environmental degradation.

Other fundamental impediments to individual producers adopting sustainable environmental management practices are poor economic incentives for implementing environmental management practices with only long term pay-backs. Firstly, a major constraint is the declining terms of trade for Australian farmers over the past 40 years at an annual average rate of 2 percent per annum (IC 1996). SEAC (1996) estimated that between 50 and 70 % of producers may not have the financial resources to implement sustainable management practices. Secondly, the market price of rural land does not in general reflect its earning capacity (SEAC 1996). This applies to capital values of the property, tax relief provided and income received. Other impediments faced by producers identified include those imposed by government regulations and other institutional arrangements (Commonwealth of Australia 1989; IC 1996).

Individual information delivery mechanisms

In a review of information delivery mechanisms used to extend the results of R&D corporation sponsored research, Woods *et al.* (1993) found that there was little objective evaluation linking information delivery processes to increased adoption of technology, greater competitiveness or better resource management practices. In particular, they found the literature was inadequate to build up a model of communications in an industry or for specific issues, as a basis for recommending future communication strategies. However Woods *et al.* (1993) made a number of specific findings relevant to the communication of natural resource issues including:

- Producers like personal communication. Farmer networks are the most powerful information exchange mechanisms for impacting on most stages in the decision-making process. However producers outside these networks are the hardest to communicate with.
- Other producers and family members are the most frequent and highest rated sources of information.
- Producers use multiple networks, seldom relying on a single resource for information, with the particular networks changing with particular issues.
- One-off group meetings can be used as a vehicle for information flows between multiple sources of information, using various information delivery mechanisms.
- Complementary information delivery mechanisms are also required to ensure producers have access to information in a format that suits their individual learning style.
- On-going groups are appropriate to all phases of problem solving and can provide a forum for inter-change between researchers, extension/advisory people and producers or landholders.
- Printed media rarely leads to change in behaviour or decision making on their own.
- Producers respond most positively to quality products from credible sources which minimise jargon.

- Computer applications have the potential to analyse farming systems and test the impact of new technology better than any other decision support tool. However applications for farmers must indicate financial consequences of different actions.

4.2 Assessing producer awareness and potential for adoption

As discussed in the preceding section, producer perceptions depend on a variety of external factors as well as the level of producer knowledge with respect to processes controlling land degradation. Actual levels of awareness for a specific issue can be seen to arise out of the overall level of interaction the individual producer has with:

- peers, for example in group activities, producer initiatives
- extension agencies
- "landcare" activities
- researchers engaged in R&D for grazing management
- resource and business planning
- sub-catchment/catchment planning activities.

The more diverse the interactions, the higher the likelihood for an increased awareness for a multitude of issues related to sustainability, and the further the individual moves from interaction limited to peers and restricted to local problems to interactions successively exposing him or herself to "bigger picture" issues through involvement in sub-catchment planning activities, the greater the acceptance of the off-site implications of agricultural production. Consequently, the level of interaction is an important indicator for the potential of research outcomes related to grazing management and catchment response to be adopted. In addition, a number of other factors also affect the potential for adoption:

- level of interaction with peers etc.
- level of trust between R&E agencies and land-holders
- current land condition
  -> want room for improvement
  -> want potential for improvement
- availability of local action plans for resource management
- socio-economic factors
  -> measure of viability
  -> property size, infrastructure
  -> perceptions:
  sustainability doesn't pay, or
  can't afford not to be sustainable, or
  pro-active ecologically based grazing management is imperative

Level of trust is an important element to bear in mind, as it will be one of the critical factors determining success or failure of adoption. Implications are the need for a high level of producer involvement in the design of research from the onset of any new major research project, to ensure that there is a mutual understanding of the respective perspectives. Furthermore, adoption will only be successful where there is an actual need, ie. in sub-catchments or catchments that are currently showing signs of increased land degradation, as there is little scope in trying to improve management where land condition is good.

Apart form these factors, a variety of socio-economic factors will ultimately drive producers decisions, irrespective of level of awareness. In many cases, although awareness and preparedness to act and adopt sustainable land use techniques may be high, financial

constraints related to property viability (in turn depending upon level of debt servicing, cost-benefit relationships), property size and infrastructure can pose unsurmountable barriers to adoption. Mingled with actual economic constraints are perceived economic constraints. In fact, we believe that some of these determinants are still not well enough understood or quantified in order to provide the basis for more efficient information delivery and adoption mechanisms to be implemented, and as pointed out in section 2.3, this is probably a major research field in its own right.

4.3 Conclusions

From the producer perspective, the non adoption of environmental management practices is understandable, logical and quite possibly rational (Vanclay and Lawrence 1995). In the context of the nature and breadth of constraints on producers discussed previously, the fundamental considerations for communication on natural resource issues to individual producers relate to:

- the need for establishing the perception of personal relevance to the individual producer of environmental management,
- understanding the adequacy of the producers knowledge of land degradation processes;
- establishing the recognition of personal responsibility in respect of the issue; and
- the need to use appropriate producer communication networks.

In terms of meeting the objectives of this study, this implies that in proposing a conceptual research framework to conduct new research on catchment management, water quality and nutrient flows as they relate to the northern beef industry, a major emphasis has to be laid on ensuring the research is adequately linked to an efficient communication strategy, bearing the above principles in mind.

With respect to assessing the potential for adoption in specific focus catchments, critical assessment criteria are seen to be:

- level of producer interactions, initiatives
- availability/vicinity/level of skills of R, D&E providers
- current levels of sub-catchment / catchment management activities

Owing to the constraints of this study, an assessment following these criteria can only be undertaken on an expert opinion basis, as time necessary to systematically collect, collate and quantify some of the above indicators was not available.

5. Conceptual framework for multi-disciplinary research into catchment management, water quality and nutrient flows as they relate to the northern beef industry

The objective of this chapter is to provide NAP3 with some recommendations on how a major multi-disciplinary multi- agency project conducting research into catchment management, water quality and nutrient flows might be best established and structured. We have chosen a multi-stage approach, indicating which the critical components are, how these link to ongoing research, and funds permitting, which additional highly desirable research components would provide a maximum added value to the core work. Following the discussion of a possible general framework, we focus on the critical components and provide some indications of likely costs and time-frames.

5.1 General framework

Based on the recommendations of Hook's review (1997), the outcomes of the 2nd workshop (see Appendix 8.3) and on the assessment and prioritisation of critical research issues in sections 2.2 and 2.3, the key sets of issues can be formulated as:

1. impacts of grazing management on sediment generation and nutrient loss at scales ranging from hillslope to catchment,

2. quantification of key determinants of sediment, nutrient and overland flow processes at various scales and their modeling to enable extrapolation to other catchments in Northern Australia.

These two topics are intricately linked with each other, requiring an efficient implementation of internal project communication. In addition, taking into account the levels of producer awareness and potential limitations to adoption of soil conservation measures as outlined in chapter 4, it will be necessary to establish a comprehensive communications strategy, to ensure effective communication both between the various research components and the potential external linkages, as well as with pro-active catchment management groups, extension services and producer initiatives.

An overview of a possible project framework is presented in Fig. 5.1, where the critical areas of research and the communication strategy have been highlighted. In addition, three highly desirable research areas have also been identified. These relate to assessing the role of climate variability, the quantification of off-site effects and research directed at improving our understanding of the socio-economic determinants of grazing management. Inclusion of these research areas into the project would clearly provide a full assessment of the beef industry's impact on catchment scale processes, both from a bio-physical as well as from a socio-economic point of view. However, if funding is limited, these topics are not as critical as addressing the scale dependant effects of grazing management on sediment and nutrient export.

A central feature of the general framework proposed here is the attempt to integrate and maximise potential linkages to ongoing work, so as to enable a concentration of potential funds on the critical components. In general terms, linking the sediment and nutrient processes work to ongoing hydrological and modeling as well as sediment sourcing research within CSIRO's Multi-Divisional Dryland Farming for Catchment Care Program (CSIRO DFCC) and the CRC's for Catchment Hydrology (CRC-CH) and Freshwater Ecology (CRC-

FE) would reduce the need to invest in catchment research methodologies and modeling approaches, as these issues form a core of the research currently being executed in the DFCC and CRC-CH programs. Needs in improved understanding of nutrient cycling dynamics, including the effects of animal defecation, as the basis of assessing potential nutrient sources from grazed land might be adequately catered for by forming strategic linkages to the nutrient cycling work within Program 1 of the CRC for Sustainable Development of Tropical Savannas (CRC-SDTS, NATT Transect).

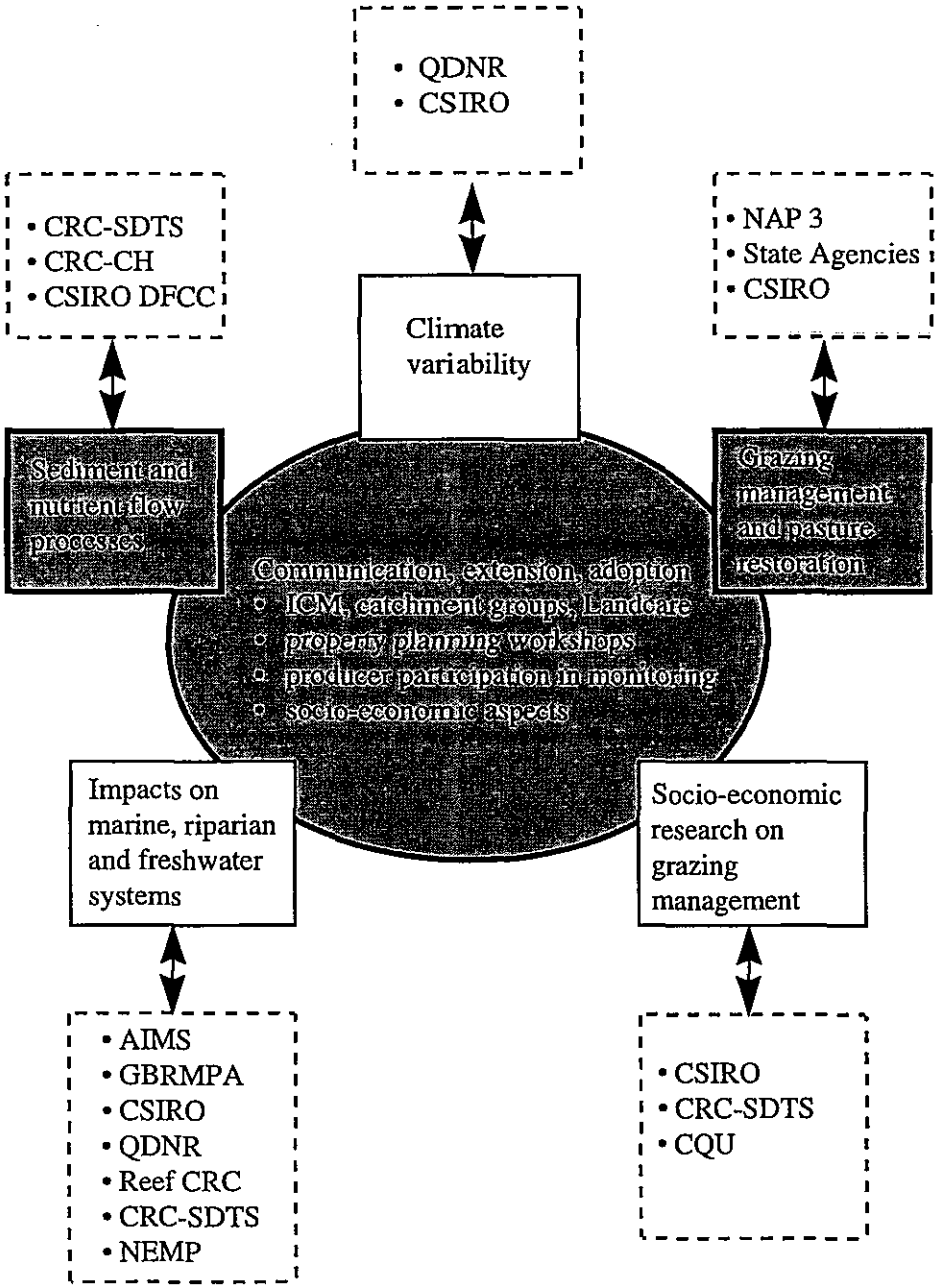

Figure 5.1: Schematic overview of suggested general research and communications framework. Shaded areas delineate critical project components, clear boxes highly desirable research components and dashed boxes represent potential linkages to existing R&D programs and providers.

A great potential for linkages also exists in ensuring that improved understanding of the relationships between grazing management and sediment and nutrient loss is channeled through to the multitude of ongoing projects targeting grazing management, particularly within NAP3 (refer to Tab. 2.3). Which individual projects might be best linked can only be established once the focus catchment/s are selected, but irrespective of location, there is scope to facilitate exchange between other NAP3 projects and the project discussed here by setting up a comprehensive communications strategy.

As already pointed out, the non critical but highly desirable research areas (off-site impacts, socio-economic research, climate variability) can probably be sufficiently catered for by strategic links. Further details on which specific research components link to which ongoing projects are given in section 5.5, following the discussion of the critical research and communication components in 5.2 and 5.3.

5.2 Critical research components

An overview of the critical research components and their linkages is presented in Fig. 5.2 and Tab. 5.1. The starting point is the compilation of all available relevant climate and land resource information and the extraction of indices of land condition and vegetative cover from aerial photos, satellite images etc. This information, coupled to a digital terrain analysis to extract key topographic parameters controlling the various forms of erosion, feeds into the central component concerned with the identification of sediment and nutrient sources in a grazed focus catchment. Whilst this seems fairly straightforward, it should be borne in mind that consistency of data across all of NA is lacking, which potentially is a major hurdle for any extrapolative work, and a greater effort needs to be undertaken to address this issue.

In the first instance, constructing a reconnaissance level sediment budget for the whole focus catchment will delineate the actual erosion "hotspots" or vulnerable sub-catchments suitable for further detailed studies (R1 in Fig. 5.2). This higher level sediment budget will be coupled to an assessment of the risk of sediment delivery and export from various regions within the focus catchment, also enabling an estimate of grazing impacts on sediment export to estuarine or marine systems at larger scale.

Following the selection of suitable sub-catchment with a high level of current or potential erosional activity, more detailed sediment and nutrient budgets are established by quantifying sources, internal deposition and export and by breaking down sediment into size classes and relating it to nutrient loss (R2 in Fig. 5.2). This spatially referenced budget needs to be closely linked to a spatial analysis of grazing management impacts ranging from hillslope to sub-catchment scale (R3). Linking these two components is the key step to assessing the impact of grazing management on sediment and nutrient loss for different land types at a range of scales.

The sediment and nutrient budgets and the spatial analysis of grazing impact in turn need to be closely linked to the assessment of the off-site effects of erosion, i.e. the impact of nutrient and water loss on pasture productivity and, ultimately, turnoff (R4). Successful assessment of the on-site impacts will also need to account for the role of different land types on the severity of soil and water loss impacts, which might be carried out through producer led monitoring (R5).

Whilst the above research components are designed to address the first set of issues as defined above, the ensuing research components are directed more towards tackling subset 2 and enhancing our process understanding to enable the development of modeling tools and

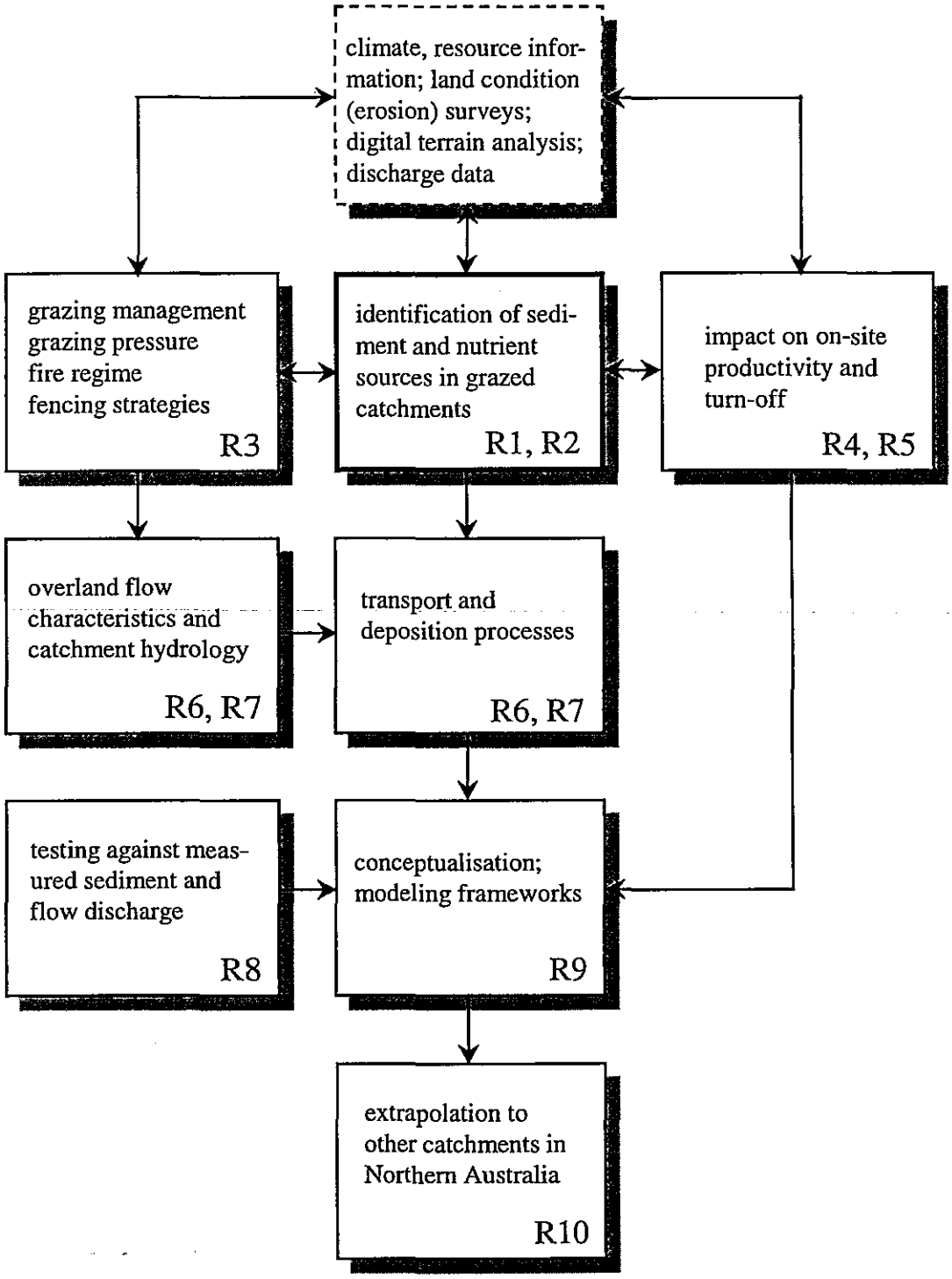

Figure 5.2: Overview of critical research components.

extrapolation techniques. At the hillslope scale, entrainment, transport and deposition of sediment and nutrients depends on the amount and characteristics of overland flow and entrained sediment and their relationship to topography and surface condition as affected by grazing management (R6). Special emphasis will be laid on establishing the size distribution of sediments at varying scales. Coarse material will be rapidly deposited as soon as transport power decreases, while finer material is transported through the system and removed by

major channels. As nutrients are closely linked to the fine fractions, it is likely that nutrient delivery is tightly related to delivery of fine sediments. At larger scales, there is a need to improve our understanding how surface hydrology affects gully and channel processes (R7). Consequently, these two separate components are critical steps in formulating robust conceptual models that in turn lend themselves to the development of numerical simulation models (R9).

It is important here to reiterate that a number of models already exist and are being refined through CSIRO's Dryland Farming for Catchment Care Program. What is lacking is information on measures of process rates typical for grazed catchments in NA to calibrate and validate these models, as well as the integration of these models into grazing systems models or Decision Support Systems (GRASP, APSIM, LANDASSESS etc.) that would enable scenario modeling of effects of changes in grazing management on long-term economic performance and off-site impacts to be undertaken.

An important feature of the modeling work proposed here is the attempt to identify key determinants of sediment and nutrient loss that can be characterised by surrogate measures more readily available in some of the data sparse environments across NA. This entails a need to "strip down" some of the existing, more complex models to simpler approaches and represents a major part of the modeling component R9 in Fig. 5.2. Whilst the quantification of detailed sediment and nutrient budgets at sub-catchment scale (R2) and the determination of overland flow and sediment and nutrient loss (R6, R7) would provide the basic dataset for the simplification of these models, testing against independent measures such as water, sediment and nutrient discharge at various points in the studied sub-catchments is a prerequisite for model validation (R8).

Hence the proposed framework provides an enormous opportunity to close a major gap in our current modeling capabilities. More importantly given the extent of the beef industry and the general paucity of key land resource and hydrological data, the development of robust models is essential if the work carried out in a particular focus catchment is to be used for extrapolation to other catchments across NA. Such extrapolation work could be carried out through follow-up projects or case studies in another contrasting NA catchment to be planned as a final research component of the proposed research program (R10).

5.3 Critical communication components

As already mentioned previously, the key to successful implementation of improved land management techniques aimed at reducing the impact of grazing on sediment and nutrient export is an increased awareness and recognition by graziers that soil erosion is a major issue in relation to long-term sustainability of grazing systems, and that prevention of erosion in the first instance is by far the most effective means of avoiding a decline in pasture productivity. As depicted in Fig. 5.3, three components influencing producer awareness can be identified. Whilst it cannot be the objective of the proposed project to instigate the formation of more catchment care groups or to run property planning workshops, there clearly is a role to facilitate the flow of information from the research components to be integrated into these two components and thus make these channels of communication more effective. In fact, during the 2nd scoping study workshop there was a clear recognition that producer involvement both in the initial formulation of the project as well as through direct participation in monitoring was a key component to increase overall producer awareness.

Ultimately, raising producer awareness is not only to build general endorsement of erosion issues (and justify industry funds being spent on catchment scale erosion research), but rather

to lead into improved management of grazing lands. In addition to acceptance, producers also need to be provided with knowledge and adequate tools; hence the necessity for a specific component to facilitate channeling of research outcomes from the proposed project as well as from other ongoing NAP3 projects and also a component that aims to package the outcomes into specific tools (Fig. 5.3). These may range from user friendly erosion assessment and management manuals and information packages designed to integrate into existing communication channels to Decision Support Systems to assist in catchment management (eg by refining existing DSS such as LANDASSESS, Bellamy *et al.*, 1996 or the DSS for natural resource management, refer to proforma No. 37).

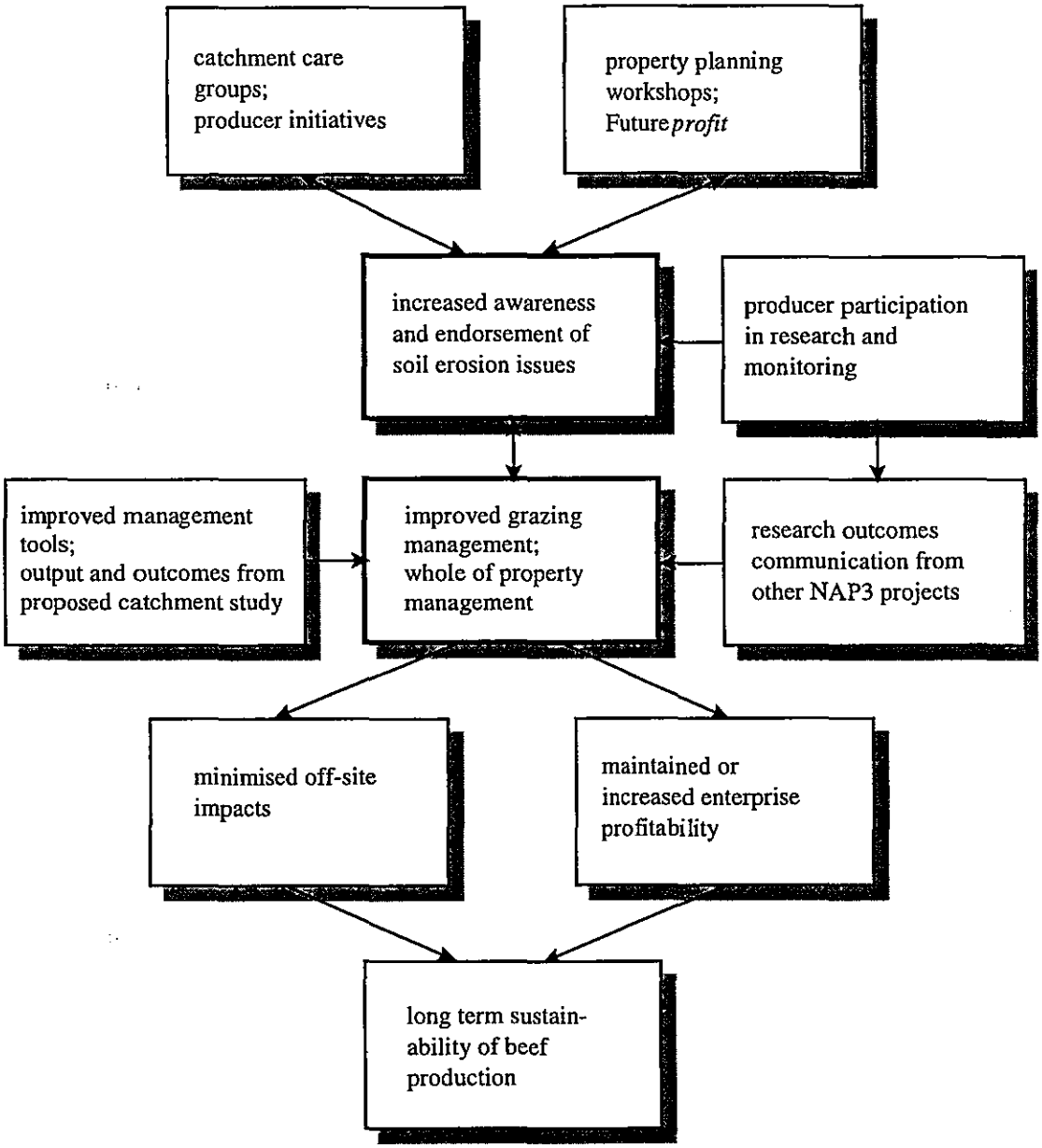

Figure 5.3: Overview of critical communication components

In fact, incorporation of refined models into DSS as discussed in the previous section, with a clear grazing systems approach, would provide an important link to the research components, as these tools could be an essential tool to evaluate the benefit of various improved land

management techniques on catchment response to minimise off-site impacts whilst maintaining enterprise profitability. This in turn could also prove to be an important feedback loop into the top components of Fig. 5.3, flowing through to further enhancement of awareness levels etc.

Not explicitly covered here, but worth noting is that there is also a need to provide communication links across NA, ie beyond the local grazing communities affected by the research in the focus catchment. It is important to incorporate this aspect into the design of the various communication components by involving extension providers across NA. External communication to other stakeholders and the broader community is an issue that is more appropriately handled through the proposed project management structure outlined in the following section.

5.4 Project management structure

Depending on the size and complexity of the envisaged research project, several options of project management may be suitable, ranging from a lead agency managing the project and subcontracting to other research and extension providers as necessary, through to an arrangement where a steering committee is established to oversee and control project management.

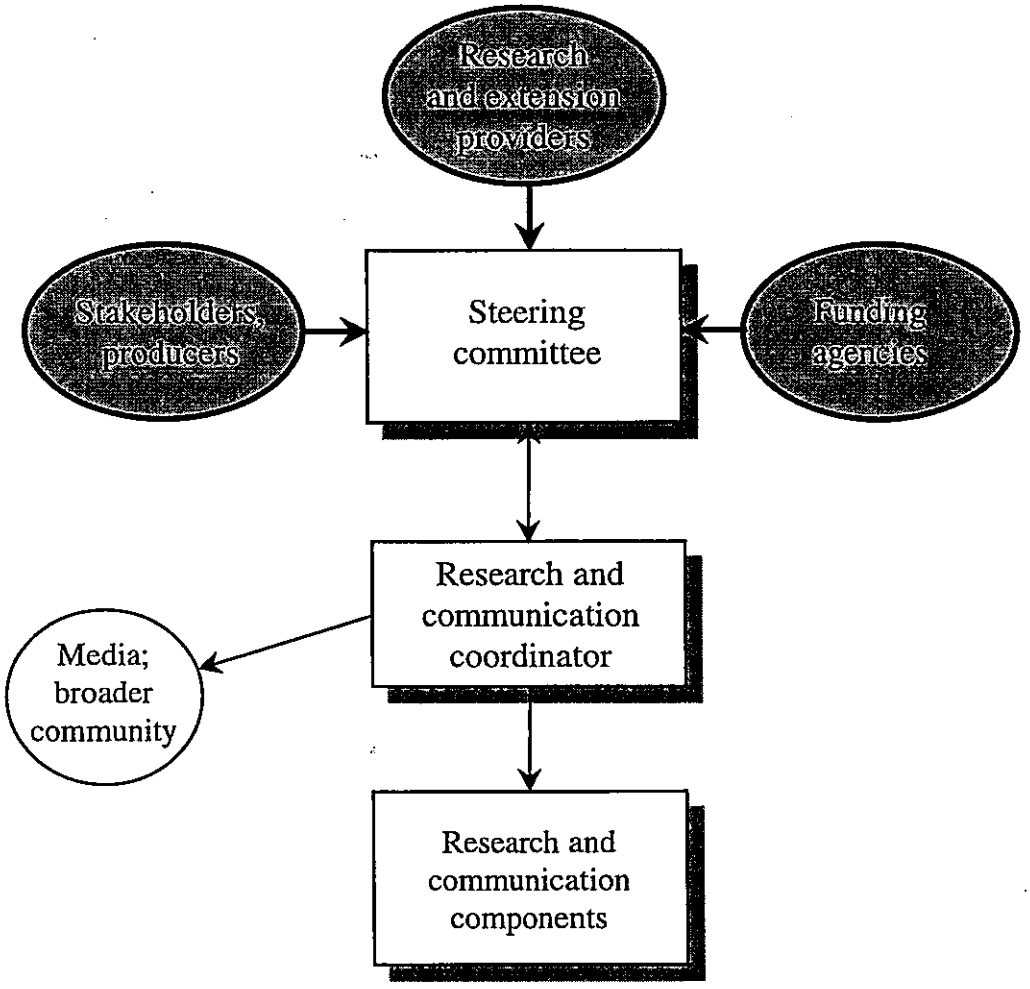

Figure 5.4: Overview of the proposed project management structure.

Considering the complexity of the research components and the requirement for a substantial communication strategy as discussed before, the option for a steering committee is seen to be the most efficient one (Fig. 5.4). It would require representation from communities, producers, the various research and extension providers directly involved, as well as representation by the funding agencies (MLA, LWRRDC, EA...). The steering committee's role is to set the objectives of the project and oversee the achievement of milestones. Responsibility for the day to day management and coordination of the various research and communication components would reside with a research and communication coordinator, respectively, who would also be members of the steering committee. In addition, the communication coordinator would also need to ensure effective and appropriate channeling of project objectives and outcomes to other stakeholders and the broader community utilising the various media.

On the basis of past experiences with major multi-agency, inter-disciplinary programs, it is critical that the coordinator's role be explicitly recognised and that the coordinator be sufficiently empowered by the steering committee to enact compliance and delivery of outcomes.

5.5 Estimation of costs and time-frames and identification of specific linkages

The objective of this section is not to provide detailed budget assessments based on specific projects, but rather to provide an approximate estimate of costs and time-frames associated with each of the critical research and communication components discussed earlier, with the clear intention of facilitating the prioritisation of future funding allocations on behalf of NAP3.

Specific research and extension providers have at this stage not been identified. In general, various universities, CSIRO and QDNR have research capabilities in catchment hydrology that cover a variety of needs associated with research components R1, R2, and R6 to R10 listed in Tab. 5.1. The Dept. of Agriculture WA, QDNR, QDPI, NTDPIF and NTDPLE are well endowed with expertise in land condition assessment and grazing management. CSIRO Land and Water has recently developed several new modeling approaches through its Multi-Divisional Programs on Dryland Farming for Catchment Care (research proformas 6, 10) and its experience in the Herbert River project (research proformas 7, 9). CSIRO Land and Water also has expertise in sediment tracing, dating and sourcing. The State agencies are major custodians of most of the relevant climate and resource information, as well as being responsible for ongoing water quality and discharge monitoring. A number of private consultants as well as the State agencies could be drawn upon to provide leadership in the communication components listed in Tab. 5.2.

The principal components are listed in Table 5.1 and 5.2 together with indications of duration of work and approximate external funding requirements. The latter are preliminary estimates based on required salary offsets for scientists and technical support staff, travel and general operating requirements. They have not been specified to a detail commensurate with proposal development as it was perceived that this was premature at this stage and therefore are likely to vary. Furthermore, costs will be affected by choice of focus catchment and selection of sub-catchments for detailed studies. These effects were not taken into account. A brief description of each module is given below.

R1 - Reconnaissance sediment budgets at catchment scale
The objective of this component is to refine the spatial analysis of potential vulnerability conducted during the scoping study within the focus catchment and complement the analysis

by a reconnaissance survey of the actual erosional activity in order to identify the "hotspots" within the selected focus catchment. These hotspots (sub-catchments) would then be the targeted areas for further detailed studies (R2 - R9). Methods employed can include photo-interpretation, compilation and assessment of existing literature, ground traverses, digital terrain analysis, sediment tracing and combinations thereof. Estimated costs will vary with the size of the area to be investigated, the scale of the analysis, whether aerial photos can be accessed or need to be purchased and to what extent sediment tracing techniques are to be employed.

Table 5.1: Cost and time-frame estimates for the critical research components. Highlighted components are fundamental to achieving the overall objectives of the project.

	Critical research components	**Duration of work (months)**	**External funding requirements ($/annum)**
R1	Reconnaissance sediment budgets at catchment scale	12	80,000
R2	Detailed sediment and nutrient budgets at sub-catchment and hillslope scale	24	120,000
R3	Spatial analysis of grazing impacts on soil and vegetation at hillslope and sub-catchment scale	24	100,000
R4	Impact of nutrient and water losses on productivity	24 - 36	150,000
R5	Assessment and monitoring of land management effects on erosion control	48 - 60	50,000
R6	Analysis of runoff and sediment generation and redistribution on hillslopes	24	75,000
R7	Analysis of sub-catchment hydrology and channel processes	36	180,000
R8	Measurement of sub-catchment sediment loads	36 - 60	120,000
R9	Sub-catchment scale sediment delivery and systems scenario modelling	12 - 24	80,000
R10	Case study extrapolation to another North Australian catchment	24 - 36	120,000

R2 - Detailed sediment and nutrient budgets at sub-catchment and hillslope scale
This component is a core activity, and owing to the higher level of detail of identification and quantification of the various sources, stores and routes of sediment and nutrient export envisaged, it can only be carried out within a restricted number of sub-catchments. These need to be both typical within the focus catchment and possibly representative for other regions in NA, as well as presenting a substantial variation in land condition and grazing management regimes. The methods use are similar to those in R1. Outcomes of this component feed into R3, by linking identified sources of sediments and nutrients in the landscape with different grazing regimes for different soil and vegetation conditions. This component will also provide the data to establish a conceptual model of sediment and nutrient flow as a basis for the development and calibration of models in R9. Estimated costs will vary for similar reasons as in R1.

R3 - Spatial analysis of grazing impacts on soil and vegetation at hillslope and sub-catchment scale
This component, which links closely to R2, aims at taking our current knowledge of point or patch scale grazing impacts on soil and vegetation to hillslope and sub-catchment scale. This requires a better understanding of animal dynamics in relation to spatial variation of grass species and fodder biomass over larger areas, the interactions with surface condition and the resultant changes in surface hydrology and sediment transport, for varying soil types and landforms. A possible methodological approach consists of coupling low altitude airborne videography with land condition assessment and relating that to the spatial distribution of different grazing pressures. This component is critical for and feeds into R6.

R4 - Impact of nutrient and water losses on productivity
This component was regarded as relatively less important, as an assessment of impacts of nutrients and water can be carried out as part of R9 as a desktop based modeling exercise using scenario techniques. Furthermore, provided an adequate sampling strategy is designed as part of R3, the preceding component should also deliver data that would allow for a quantification of on-site productivity effects.

R5 - Assessment and monitoring of land management effects on erosion control
This research component aims at assessing a range of land management techniques designed to rehabilitate degraded rangelands by monitoring the effects of improved land condition on the reduction of visible signs of soil erosion. It is potentially of high practical value to the graziers, but was regarded of lesser priority not so much because of a perceived lower degree of importance, but more because it is a component that could be integrated into ongoing activities or projects within NAP3. It also lends itself to enhancing producer involvement, and as such the issues targeted through this component might also be adequately covered through BEEFPLAN and some of the communication components.

R6 - Analysis of runoff and sediment generation and redistribution on hillslopes
This component essentially aims at providing information on rates of runoff and sediment generation for the different grazing pressure/surface condition configurations studied within R3 and is critical to improve our process understanding at hillslope scale. As such, R6 will provide information on processes of sheet and rill erosion and their intensity with particular focus on quantifying to what extent sediments and nutrients actually leave the hillslope and reach drainage lines, or eroded material is merely redistributed along the hillslope, increasing the variability of biomass as a function of erosion/deposition induced variations in nutrient and water availability. The methodological approach is centered around quantifying the hydrological and sediment detachment parameters by a combination of rainfall simulation/runoff monitoring for specific surface conditions based on Tongway and Hindley (1995) and obtained from R3. This point and patch information is then used in a GIS

framework to model hydrological response for predetermined hillslope conditions and geometries.

R7 - Analysis of sub-catchment hydrology and channel processes
This component is critical to improve our understanding of gully and channel erosion dynamics. In many cases, gullies and channels are the principal source of sediments leaving a catchment. Whilst gully erosion is often triggered by the management and hydrology of the watershed above the gully head, actual process control is strongly dependant on topographical parameters. Little work has been done in Australia in general and in NA in particular to provide an improved rate and process understanding of the above dynamics. In terms of methodology, a strong link exists between R6 and this component, as hillslope hydrology is a key input. This component would require a substantial experimental component, in particular to examine how the generation of turbidity in streams is related to the power of flows and bank loosening processes such as wetting and drying and stock trampling. Principal outcomes would be in form of inputs to R9 and guidelines how to improve stock management along riparian zones.

R8 - Measurement of sub-catchment sediment loads
This component is complementary to R2, and is principally required to produce an independent data set to validate the sediment budget techniques used in R2, as well as providing a validation data set for model testing in R9 and to ensure that the models developed in R9 are sufficiently robust to enable extrapolation to other NA catchments. The work required is essentially of a monitoring nature, and costs are mainly associated with the setting up of automated water sampling stations at key locations within the more intensively studied sub-catchments and operating costs for sample analysis (total suspended sediments, N and P). Depending on the choice of focus catchment and selection of sub-catchments, there is scope to reduce costs somewhat by linking into ongoing sampling activities carried out by QDNR.

R9 - Sub-catchment scale sediment delivery and systems scenario modelling
The main aim of this component is to develop simplified catchment models that enable the assessment of grazing impacts be carried out for other grazed catchments with a greatly reduced amount of available data, a situation typical of most NA. To meet this objective, sediment delivery models currently being developed within CSIRO Land and Water or other suitable models need to be tested and modified against the detailed information gathered in components R2, R3, R6 and R7, and simplified to a point that they are still sufficiently reliable to run on a greatly reduced amount of model parameters that can be readily derived from existing land resource information (AUSLIG DEMs, SLATS or other satellite land condition information, geology). Once established, the models can also be used to conduct what if scenarios to more systematically assess grazing management impacts on catchment response. Therefore, besides providing an indispensable extrapolation tool, a major outcome could be a the establishment of guidelines for more sustainable catchment management practices in the NA grazing industry.

R10 - Case study extrapolation to another North Australian catchment
This component was considered to be of lesser importance than the preceding ones, as it is not strictly critical to achieving the stated overall objectives. In addition, it is feasible that this component be funded out of other initiatives (eg FRDC/LWRRDC initiative to support work on land use impacts on the northern prawn fisheries industry in a selected northern coastal catchment - scoping study currently being conducted by CSIRO Marine Research and CSIRO Tropical Agriculture).

A similar approach as above follows for the communication components.

Table 5.2: Cost and time-frame estimates for the critical communication components. Highlighted components are fundamental to achieving the overall objectives of the project.

	Critical communication components	Duration of work (months)	External funding requirements ($/annum)
C1	Development of communication packages to raise producer awareness	12	50,000
C2	Integration of catchment process information and output from other NAP3 projects into property planning workshops	24 - 36	70,000
C3	Facilitation of producer participation and involvement of other ongoing producer based initiatives	36	50,000
C4	Development of erosion assessment manual and conservation guidelines manual for producers	24	80,000
C5	Producer run integrated grazing management trials	36	50,000
C6	Communication to producer groups across NA	24	50,000

C1 - Development of communication packages to raise producer awareness
The model in mind for this component is the current attempt within NAP3 to ensure that outcomes from the soil acidification project (Noble, NAP3.218) are directly translated into producer friendly outputs (Middleton, NAP3.220). It is envisaged that similar a framework be established between specific research components (eg R2, R3, R6, R7) and C1.

C2 - Integration of catchment process information and output from other NAP3 projects into property planning workshops
Development of communication packages in C1 is an important input to C2. However, the main thrust of this component is to involve producers, extension providers and researchers in joint property planning workshops with a strong training component in identifying signs of degradation and selecting appropriate management options to manage soil erosion.

C3 - Facilitation of producer participation and involvement of other ongoing producer based initiatives
Of all communication components, C3 is regarded as the most critical. This component is mainly targeted at increasing producer endorsement of land degradation issues by involving them in project development and where possible, through linkages to ongoing producer driven initiatives (eg NHT funded projects, BEEFPLAN). Amongst other things, funds are required to offset time in monitoring activities invested by producers to meet some of the needs of R3, R4 and R5 or to provide consultancy support within the BEEFPLAN framework.

C4 - Development of erosion assessment manual and conservation guidelines manual for producers
Considering the lower acceptance rate for printed media compared to other channels of communication, this component was regarded of lowest priority. The original concept was to build upon existing land and soil condition assessment manuals (eg Tongway and Hindley, 1995) by simplifying these into producer friendly formats and supplemented by research outcomes from R3 to R7. As such C4 would link into C1.

C5 - Producer run integrated grazing management trials
This communication component probably can be covered through BEEFPLAN and therefore is also considered of lesser importance than C1 to C3.

C6 - Communication to producer groups across NA
Depending on their design, it is feasible for this component to be integrated into C2 and C3 and consequently was also considered of lesser priority.

Sequencing of the individual components is shown in Fig. 5.3. As can be gathered, the full project would require funding over a period beyond the life of NAP3, in particular as R4, R7, R9 and R10 require several years lead time before they can be initiated. Costs of research and communication coordination were put at 20000/annum (salary offsets and operating).

Table 5.3: Timelines of research components (R1 - R10, refer to Tab. 5.1), communication components (C1 - C6, refer to Tab. 5.2) and coordination activities (CO).

Activity	1998	1999	2000	2001	2002	2003	2004
R1							
R2							
R3							
R4							
R5							
R6							
R7							
R8							
R9							
R10							
C1							
C2							
C3							
C4							
C5							
C6							
CO							
Total	170,000	632,500	1,005,000	1,102,500	965,000	635,000	130,000

Not assessed in the study was the likelihood of attracting other funding bodies (DEST, GBRMPA, RIRDC, FRDC etc.) to join the initiative, but we recommend that MLA and LWRRDC follow up this aspect with the potential research providers in the event of a decision to progress this work.

An overview of potential specific linkages of the proposed research components with ongoing research projects as listed in section 2.1 (Tabs. 2.2 - 2.6) is given in Tab. 5.4. Again, which specific linkages will actually materialise is dependant on the focus catchment and the precise location of some of the proposed hillslope and sub-catchment scale work.

Table 5.4: Matrix of linkages between proposed research components as listed in Tab. 5.2 and ongoing research projects as listed in Tab. 2.2 to 2.6.

Research and communication components in Tab. 5.1 and 5.2	**Projects listed in Tab. 2.2**	**Projects listed in Tab. 2.3**	**Projects listed in Tab. 2.4**	**Projects listed in Tab. 2.5**	**Projects listed in Tab. 2.6**
R1	2, 8, 9	21	26, 28, 30		
R2	2, 8, 9	21	26		
R3	1, 3	12,13,14,15,19			
R4		11	29		
R5		10, 22			
R6	3, 5, 7	11, 13, 14			
R7	8, 9			33	
R8			26		
R9	5, 6			33	
R10					
C1	1, 7	12, 14, 20, 24,	25		34, 35
C2	1	12, 20	25		34, 35
C3		12, 20	25		34
C4					
C5		BEEFPLAN			
C6					

In addition, external factors such as the decision of the CRC for Sustainable Development of Tropical Savannas to focus its future Queensland based work in the Burdekin, and the outcome of the current strategic planning within the CRC for Catchment Hydrology and CRC Freshwater Ecology to select the Fitzroy catchment as its tropical catchment is likely to have an impact on the degree of added value to the work proposed here.

5.6 Recommendations

Considering the complexity, longevity and costs associated with the establishment of a major project to conduct research into grazing management impacts on sediment and nutrient export, we recommend that:

- the project be focussed around critical research components addressing the impacts of grazing management on sediment generation and nutrient loss at scales ranging from hillslope to catchment scale and the identification of key determinants of sediment,

nutrient and overland flow processes at various scales and their modeling to enable extrapolation to other catchments in Northern Australia

- the research components be complemented by an effective communication strategy in turn comprising several critical components
- that the research components be designed as to maximise links to existing research, particularly in the fields of off-site impacts and research into the socio-economic determinants of grazing management
- the project be managed through a steering committee in liaison with a project coordinator responsible for research and communication coordination,
- the overall project be spread beyond the time frame of NAP3

6. Selection of potential focus catchments

6.1 General procedure

Given the time and resource constraints of the study, it was decided to proceed through a three-step screening approach using a combination of GIS analysis techniques and expert opinion inputs as the most appropriate procedure to identify suitable focus catchments.

The first step consisted of undertaking an assessment of intrinsic or potential vulnerability of NA catchments to soil erosion, based on a GIS spatial analysis. The outcome of this step are maps differentiating the relative potential for sheet/rill and gully/channel erosion, respectively, and a relative ranking of NA catchments with respect to overall intrinsic vulnerability.

This step was followed by an evaluation of the relevance of NA catchments to the beef industry. This step required the compilation of relevant cattle production statistics and a GIS supported calculation of stock densities taking into account actual grazing land in each catchment. Output from this step was a relative ranking of relevance for the northern beef industry.

The top ranked catchments resulting from both steps were then assessed on an expert opinion basis to narrow down the number of catchments into a small group of short-listed potential focus catchments. These were then analysed in greater detail in section 6.4, following a predetermined set of criteria, before a final ranking of potential focus catchments was undertaken.

6.2 Assessment of intrinsic vulnerability

Intrinsic or potential vulnerability was chosen as a means of characterising and ranking catchments in the first step on the basis that information in digital format about spatial distribution of key determinants of soil erosion is more readily available than information on actual occurrence and intensity of erosional activity across all of NA. Guiding principles for step 1 were:

- a need to differentiate between sheet/rill and gully/channel erosion processes
- screening procedure must lend itself to a GIS analysis approach
- outputs need to be cross-checked against local knowledge where available for specific catchments (reality check) or other appropriate measures

Whilst this offers the possibility of evaluating risk across all of NA, we need to point out that the shortcoming of this approach is that areas of moderate to low intrinsic vulnerability exerted to excessive grazing pressure may well evidence higher levels of actual erosion than areas with a high intrinsic vulnerability but low grazing pressures.

Determination of sheet and rill erosion indices

The assessment of intrinsic vulnerability to sheet and rill erosion was based on an approach recently taken by Rosewell (1996) in his contribution to the State of the Environment Report. This approach is founded on the Revised Universal Soil Loss Equation - RUSLE, and estimates yearly average unit area soil loss (A, t/ha/yr) as a product of the erosion factors rainfall erosivity (R), soil erodibility (K), a combined slope steepness and length factor (LS), a vegetation cover factor C and a soil protection factor P:

$$A = R \cdot K \cdot LS \cdot C \cdot P \qquad [1]$$

The advantage of selecting this approach is that digital coverages for each factor already exist and are accessible through ERIN. However, during the discussions in the 1st workshop, it became apparent that this approach is not sufficiently tested in Australia to warrant the expression of sheet and rill soil loss in absolute terms (t/ha/yr), so a decision was taken to use the approach for a relative ranking only (for a more detailed discussion of the reliability of the approach refer to Rosewell, 1996). In doing so, we calculate what essentially is a dimensionless index for potential sheet and rill erosion (I_{SR}). As the soil protection factor is irrelevant to grazed land, it was not further considered. Furthermore, it was decided to recalculate the slope steepness factor using the AUSLIG 9" digital elevation coverage of Australia, as in Rosewell's original approach the LS factor had been derived from landform information rather than actual slope. Consequently, I_{SR} was calculated on a 1000 x 1000 m grid resolution in ARCINFO following:

$$I_{SR} = R \cdot K \cdot S \cdot C \qquad [2]$$

with:

- erosivity R	(ERIN coverage, 2000 x 2000m grid)
- erodibility K	(ERIN coverage, 2000 x 2000m grid)
- slope factor S	(calculated from AUSLIG 9" DEM; 250 x 250m grid)
- vegetation factor C	(ERIN coverage, 2000 x 2000m grid)

For more information on the ERIN coverages refer to Website:
http://www.environment.gov.au/edd/owa/edd_search2.Browse_Citation?txtSession=236

Distribution and magnitude of indices of intrinsic vulnerability to sheet and rill erosion across NA are shown in Map 6.1. High indices were observed within the regions of pronounced topography (Pilbara, Kimberley, Coastal Escarpment in Qld). A combination of high soil erodibility (mostly QLD) and moderate to high erosivity (roughly following an isohyete 300 km parallel to the coastline) lead to the broad spatial distribution of moderate indices within the flatter catchments, particularly in south eastern and central parts of QLD. A detailed compilation of results is presented in Tab. 8.5A in Appendix 8.5, where average and median indices are listed for each catchment, as well as measures of variability (range, standard deviation of indices) and an integrative measure (sum of indices for all grid cells within a catchment polygon).

Determination of gully and channel erosion indices
Choice of an appropriate method to evaluate indices of intrinsic vulnerability to gully and channel erosion proved more difficult, as to date no reasonably well tested methods for the scale in question (1:5,000,000) could be directly drawn upon. The 1st workshop spent considerable time on discussing various options, the outcome of which was to perform the analysis in analogy to the sheet /rill assessment. Factors selected to determine the relative index of potential for gully and channel erosion (I_{GC}) were rainfall erosivity R, drainage density (DD, km/km^2), slope (S) and subsoil erodibility (K_{sub}):

$$I_{SR} = R \cdot DD \cdot S \cdot K_{sub} \qquad [3]$$

with:

- erosivity R	(ERIN coverage, 2000 x 2000m grid)
- subsoil erodibility K_{sub}	(ranking of soils in Austr. Atlas of Soils, 250 x 250m grid)
- slope factor S	(calculated from AUSLIG 9" DEM; 250 x 250m grid)
- drainage density DD	(ESRI coverage, 1000 x 1000m grid)

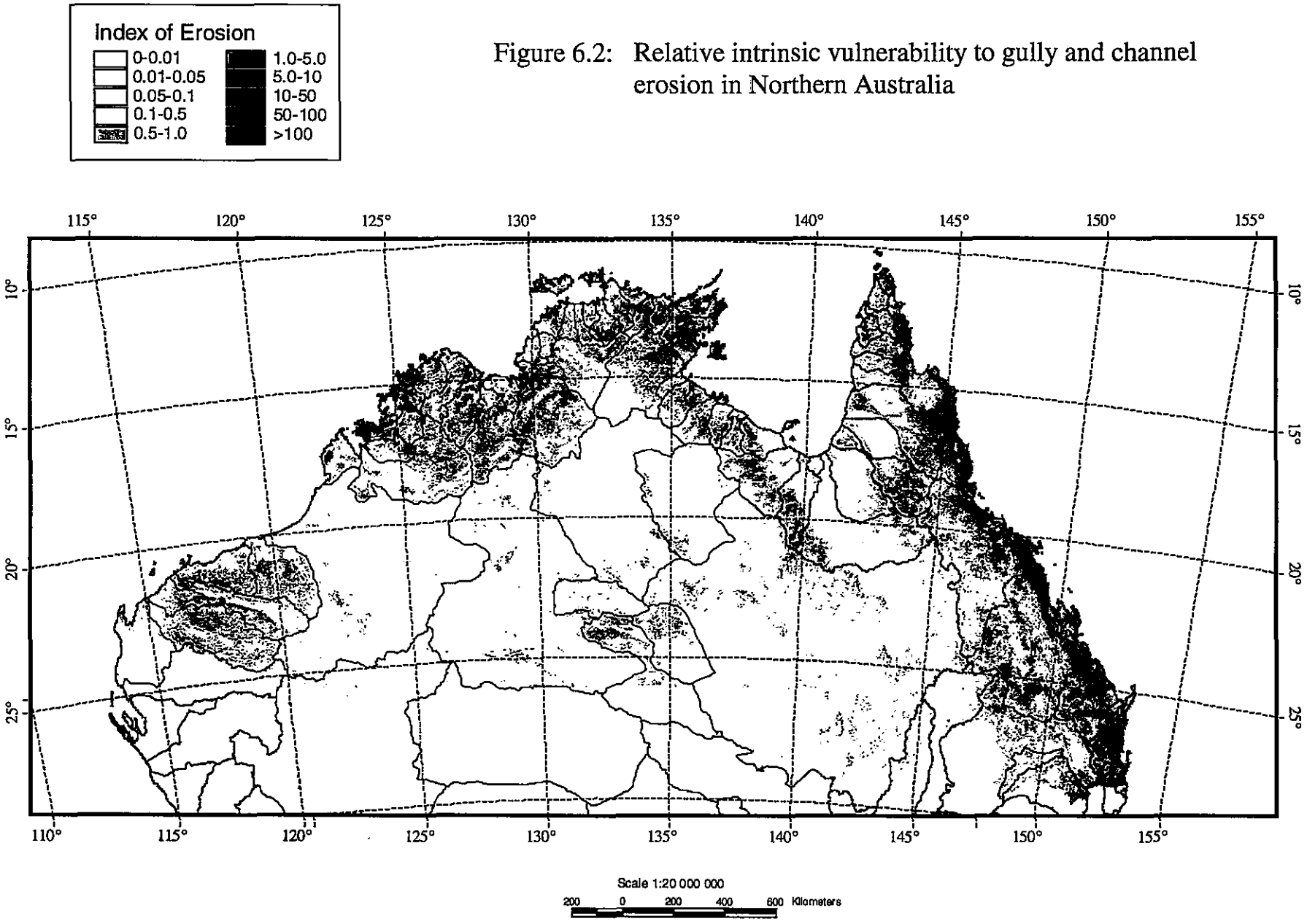

Figure 6.2: Relative intrinsic vulnerability to gully and channel erosion in Northern Australia

It would have been preferable to utilise Fournier's rainfall index instead of the erosivity factor R, as it better accounts for rainfall seasonality, but the time constraints did not allow for the production of a coverage based on this rainfall index. Drainage density was selected on the basis of the observation that it is positively related to channel erosion (R. Wasson, pers. comm.) and as such serves as a useful surrogate for sediment discharge. It was calculated from an existing drainage line coverage utilising the LINEDENSITY command in ARCINFO, which calculates the density of lines in a circular neighbourhood around each output grid cell. Subsoil erodibility was assigned to three classes (low, moderate, high) by expert assessment (R. Isbell, pers. comm.) based on the soil orders in the NRIC coverage of the Australian Atlas of Soils.

Distribution and magnitude of indices of intrinsic vulnerability to gully and channel erosion seem to be predominantly slope dependent, exceptions being areas of high rainfall erosivity and high drainage density such as Arnhem Land (NT) and parts of the Burdekin and Fitzroy in QLD. Detailed results are presented in Tab. 8.5B in Appendix 8.5.

Catchment ranking

Ranking of catchments for both forms of erosion was performed using three criteria extracted from Tab. 8.5A and 8.5B, respectively:

(i) median index
(ii) standard deviation
(iii) catchment size

The median index for each catchment was preferred to the mean as the distribution of indices in many cases was highly skewed. Standard deviation was included to reflect variability within a catchment, an important characteristic for selecting the focus catchment, as catchments containing hotspots with high erosional activity alternating with areas of low activity are more suitable to conducting the research proposed in section 5.2 than catchments showing little variation. Catchment size was included as a weighting parameter to compensate for the fact that the median indices tend to systematically decrease with catchment size and to remove some of the bias introduced by extremely large catchments (eg Diamantina) or very small coastal catchments with high indices.

Using the above ranking criteria, ranking with respect to both forms of intrinsic vulnerability was obtained from:

Ranking for I_{SR} = ((rank of median I_{SR} + rank of STDEV I_{SR})/2 + rank of catchment area)/2 [4]

Ranking for I_{GC} = ((rank of median I_{GC} + rank of STDEV I_{GC})/2 + rank of catchment area)/2 [5]

Overall ranking of intrinsic vulnerability was achieved by averaging the ranking indices:

Intrinsic vulnerability = (rank of sheet erosion + rank of gully erosion)/2 [6]

The top 30 catchments are listed in order of overall vulnerability in Tab. 6.1, together with individual sheet/rill and gully/channel ranks. The top ten catchments consistently showed the highest ranks for both indices. No clear groupings were discernible, but rather, overall ranking indices calculated from [4] and [5] tended to show steady increases, so that an arbitrary cutoff at catchment rank no. 30 was chosen (representing approx. 25 % of all NA catchments). Location of the top ranked catchments in NA is presented in Map 6.3.

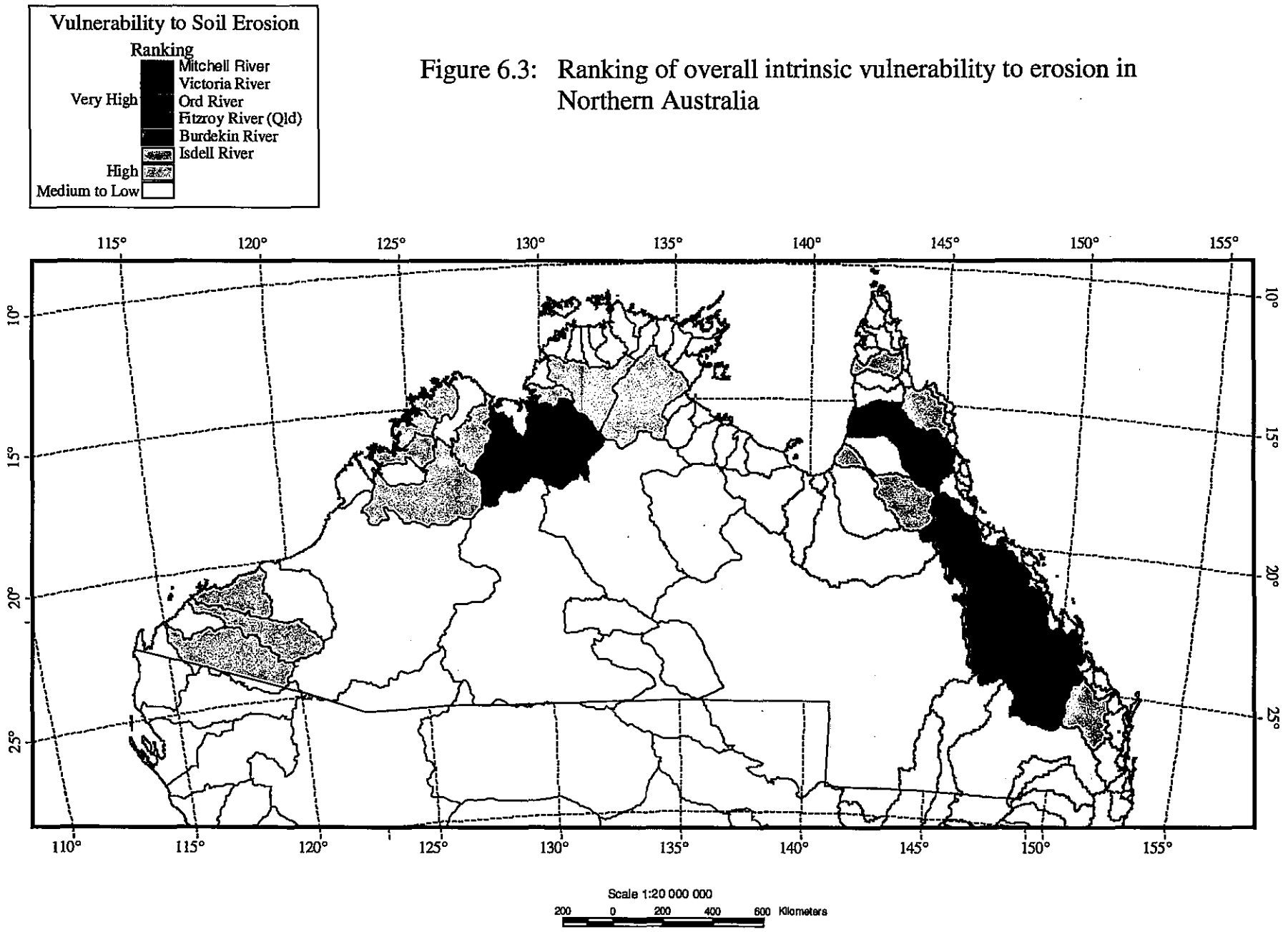

Figure 6.3: Ranking of overall intrinsic vulnerability to erosion in Northern Australia

Table 6.1: Top 30 ranked catchments across NA with respect to overall ranking of intrinsic vulnerability to erosion and ranking orders for sheet/rill and gully/channel erosion (for indices used in ranking refer to Tab 8.5A and 8.5B in Appendix 8.5)

Name of Division	Catchment Name	Area (Km^2)	Sheet/rill Ranking	Gully/chan. Ranking	Overall ranking
Gulf Of Carpentaria	Mitchell River	71321	3	2	1
Timor Sea	Victoria River	75687	2	5	2
Timor Sea	Ord River	55247	1	6	3
North-East Coast	Fitzroy River	142389	9	1	4
North-East Coast	Burdekin River	130042	8	3	5
Timor Sea	Isdell River	19158	4	8	6
North-East Coast	Normanby River	24536	6	7	7
Timor Sea	Pentecost River	27479	7	9	8
Timor Sea	Prince Regent River	14769	10	13	9
Timor Sea	Fitzroy River	91243	5	19	10
Gulf Of Carpentaria	Gilbert River	46218	16	10	11
Gulf Of Carpentaria	Roper River	78059	13	14	12
North-East Coast	Burnett River	33262	25	4	13
Indian Ocean	Ashburton River	74430	17	12	14
Timor Sea	King Edward River	17032	12	17	15
Indian Ocean	Port Hedland Coast	34341	14	20	16
Gulf Of Carpentaria	Archer River	13740	21	15	17
Indian Ocean	Fortescue River	48317	11	25	18
Timor Sea	Fitzmaurice River	10262	24	16	19
Timor Sea	Daly River	51311	19	24	20
Indian Ocean	De Grey River	56131	27	23	21
Murray-Darling	Condamine-Culgoa Rivers	132227	35	18	22
Gulf Of Carpentaria	Flinders River	109434	23	33	23
North-East Coast	Jeannie River	3444	28	29	24
North-East Coast	Olive-Pascoe River	4008	29	30	25
Gulf Of Carpentaria	Leichardt River	33242	18	41	26
Timor Sea	Drysdale River	25117	36	28	27
Lake Eyre	Diamanthina River	720573	30	36	28
Timor Sea	Lennard River	14276	20	48	29
Gulf Of Carpentaria	Nicholson River	52105	26	44	30

Assessment of reliability

As already pointed out earlier, [2] and [3] rely on many assumptions, some of which have been tested to some degree in parts of Australia, but not in NA, and others based merely on our current general understanding of geomorphological processes.

Even though [1] is derived from the fairly extensively tested methodology applicable to the USA and modified by Rosewell (1993, 1996) to fit conditions in Australia, there are some severe shortcomings. Apart from the fact that little quantified information is available on how applicable the RUSLE/USLE concept is to catchment scale processes (as it essentially is based on plot scale experimentation), Rosewell (1996) himself points out some of the weaknesses of the individual factors. In the context of this study, the K and C factors were seen to be the least reliable. In the first case, we noted some clear erroneous classifications of K, in that large areas of stable black cracking clays in the Mitchell grass plains of NA were assigned relatively high K values, probably as a result of extrapolation from cropped and

more degraded vertisols of south-eastern QLD. Similarly, K was probably overestimated for extensive hilly or mountainous areas in the Kimberley and the Top End, where slopes are characterised by outcrop and are often devoid of soils. With respect to the C factor, two issues need to be considered. In the first instance, we are uncertain how well the C factor established by Rosewell (1996) reflects the current vegetative cover, in particular some of the extensive areas cleared of trees in QLD. Furthermore, the C factor does not take into account that fire is a widespread occurrence in northern WA and the NT, effectively reducing ground cover to very low levels at the onset of the rainy season.

With respect to the assessment of intrinsic vulnerability to gully and channel erosion, the main problem lies in the question of whether individual factors in [3] have been properly weighted. In the form used, erosivity and slope are the main factors. Possibly drainage density should have been given a greater weighting, which would have somewhat modified the results. In absence of a reliable basis from which to derive appropriate weighting factors, it would have been necessary to review existing land systems and land resource information with respect to observed and assumed high potential erosion and use that information as a basis for calibration in a series of iterations of GIS analysis, where the relative weighting of the factors in [3] was modified until a 'best fit' was achieved by matching output with existing evidence on erosion potential. This approach was clearly beyond the scope of the present study but it is believed worthy of following up in the future.

Nevertheless, two options open to independently assess the reliability of the above analysis were available. One was to utilise the sum of erosion indices from all grid cells within a catchment as a surrogate measure of total potential sediment discharge and to plot that data against data of total discharge of runoff for individual catchments as available in AWRC (1976). The underlying assumption is that if our results are reasonable, we could expect some relationship between total water discharge and the surrogate measure of sediment discharge (bearing in mind that only approx. 20 catchments in NA are more than 50 % gauged and reliability of discharge data is probably equally questionable). The second option was to compare the sheet/rill and gully/channel erosion indices obtained for the Upper Burdekin catchment with actual survey data contained in Rogers *et al.* (1998) following the conversion of the UMAs mapped by Rogers *et al.* (1998) into grids.

Results of relationships between sums of sheet/rill indices and gully/channel indices and total discharge are illustrated in Fig. 6.4. Although there is considerable scatter, a highly significant linear relationship was observed. Conversely, the relationship shown in Fig. 6.5 between the erosion classes surveyed by Rogers *et al.* (1998) for each of their mapping units and the natural logarithm of median indices calculated for each UMA was not quite as tight. However there was a distinct trend for higher indices to be associated with the higher class values for both forms of erosion. The high level of scatter is probably mainly due to scale effects and the fact that intrinsic erosion susceptibility is being compared to actual surveyed erosion.

Nevertheless, both results lead us to believe that the indices of intrinsic vulnerability obtained here are sufficiently robust to warrant their use in the ranking procedure and thus provide a reasonable basis for the objectives of this study. **However, we caution against taking these results (in particular Figs. 6.1 and 6.2, Tab. 8.5A and 8.5B) beyond the level of the assessment performed here, as the uncertainties associated with the assumptions underlying equations [2] and [3] bear a high probability of errors of index classification occurring in specific points. The latter is particularly true of the assessment of gully and channel erosion.**

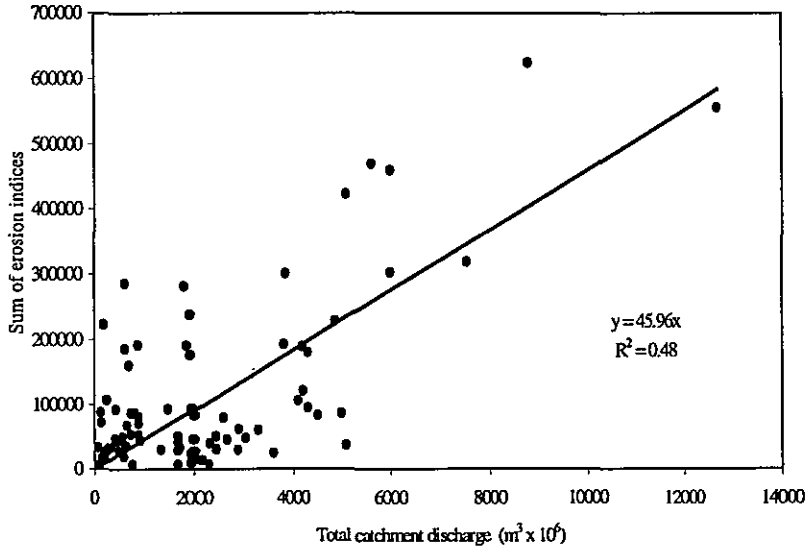

Figure 6.4: Relationship between total discharge and sum of sheet/rill and gully/channel erosion indices

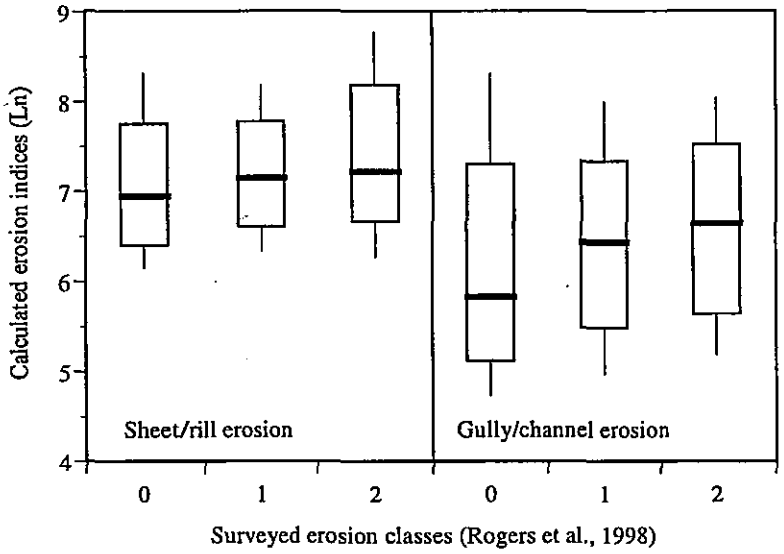

Figure 6.5: Relationship between UMA based erosion classes surveyed by Rogers *et al.* (1998) for the Upper Burdekin (0=nil to low, 1=moderate, 2=high) and the natural logarithm of erosion indices calculated for the same UMAs using equations [2] and [3]. {Boxplots represent 10th, 25th, 75th and 90th percentiles and the bold bar the median, respectively}

6.3 Relevance of catchments to the beef industry

Having identified the catchments with the highest likelihood of sediment and nutrient export in the event of excessive grazing pressure, the next step is to assess which of the highly vulnerable catchments is currently of relevance to the beef industry.

Criteria used in ranking catchments
The scoping study group decided that relevance of a catchment to the beef industry depended:

(i) on the numbers of cattle in the catchment,
(ii) the beef turnoffs from the catchment,
(iii) the relative productivity of the grazing lands in the catchment ie. cattle stocking rates in animals/ha and
(iv) the percentage of the catchment that is used for grazing.

(i) Cattle numbers in the catchment
Cattle numbers from Australian Bureau of Statistics shire data for the five-year period 1992-96 were used in the calculations. Shires of northern Australia are shown in Fig. 6.6. Cattle numbers were averaged over the 1992-96 period and aggregated into catchments in ARCVIEW. Where a number of shires occur within a catchment we are relatively confident of the predictions within the limitations of the ABS shire data set. Where shires overlapped catchments, or were bigger than catchments, the cattle were proportionately allocated across catchments. There is therefore less confidence in cattle numbers for these catchments.

The ranking of catchments according to cattle numbers is shown in Tab. 6.2

(ii) Beef turnoffs in catchments
Beef turnoffs in catchments were calculated using similar ABS data over the same five year period of 1992-96. The same limitations and errors stated above apply in calculating beef turnoffs for catchments. In addition, a degree of bias is introduced by data from catchments with high proportions of cattle produced in feedlots (eg. Border Rivers, Burnett, Moonie, as evidenced by the ratio of turnoff to stock). However, at report compilation, we did not have sufficient data for all of NA to systematically differentiate between turnoff from feedlots and grazing.

The ranking of catchments according to beef turnoffs is shown in Tab. 6.3.

(iii) Relative productivity of grazing lands
The relative productivity of catchments was estimated by dividing cattle number in the catchment by the total grazed area of the catchment to produce a catchment stocking rate in animals/ha. Within grazed catchments not all land is used for grazing. To calculate the area of grazed land in catchments we used the AUSLIG GIS coverage of Land Tenure for Australia (1:250 000). This coverage categorises land according to leasehold, freehold, vacant crown land, aboriginal lands, defence, mining, national parks etc. Freehold and leasehold land is not separated into grazing and cropping land so we added a cropping lands coverage of Australia to help us obtain the area of grazed land. This land use/land tenure map for northern Australia is shown in Fig. 6.7. Grazed land in a catchment was calculated as: Freehold + Leasehold + Aboriginal Leasehold – Cropping. In catchments where there is both sheep and cattle grazing the productivity of the land used for beef cattle may be underestimated as the cattle are allocated to the total grazed area in the catchment. Furthermore no account could be taken for additional grazing pressure originating from feral animal and kangaroo populations.

The ranking of catchments according to beef productivity per unit land area is shown in Tab. 6.4.

(iv) Proportion of land area within catchments used for grazing.
The total area of land used for grazing (as calculated in (iii) above) as a percentage of total catchment area was calculated to give an estimate of beef industry relevance on a land use basis. Fig. 6.8 shows the area of northern Australia used for grazing of domestic livestock.

The ranking of catchments according to percentage of catchment used for grazing is shown in Tab. 6.5

(v) Overall rankings
The rankings from (i) to (iv) above were averaged to produce an overall ranking of relevance to the beef industry. This overall ranking is shown in Tab. 6.6, whilst Fig. 6.9 shows the top six ranked catchments, individually colour-coded, the next fourteen ranked catchments in orange and the remainder in green.

There were no obvious groupings of catchments according to their overall ranking of relevance i.e. the average rankings from top to bottom ranked catchments were fairly evenly spread. To further explore natural groupings of catchments, the NA catchments were subjected to a cluster analysis using the four variables (i-iv) above with the statistical program SYSTAT. The first three groups (comprising most of the important beef catchments in northern Australia) separate out into interesting geographic groupings. Group 1 contains catchments mainly in north, north-west and western Queensland with relatively high beef numbers, a high proportion of the catchment as grazed land (75 – 95%) and moderate to low productivity per unit land area (0.02 – 0.09 animals/ha). Group 2 contains catchments in central and south-east Queensland with relatively high beef numbers, a moderate proportion of the catchment as grazed land (40 – 75%) and high productivity (0.21 – 0.30 animals/ha). The third main group to emerge contains small Queensland coastal catchments that have relatively small numbers of cattle but the relatively low proportion of land that is used for grazing in these catchments (15 – 55 %) is highly productive (0.20 – 0.75 animals/ha). Fig. 6.10 shows these three groupings of catchments.

Table 6.2: Ranking of catchments according to beef cattle numbers (average of 1992-96)

Rank	Catchment	Cattle no.	Rank	Catchment	Cattle no.
1	Fitzroy River	2286294	55	Prince Regent River	21353
2	Diamantina River	1410469	56	King Edward River	20151
3	Burdekin River	1116880	57	Keep River	19764
4	Condamine-Culgoa River	932479	58	Johnstone River	19371
5	Flinders River	562396	59	Plane Creek	16987
6	Burnett River	558546	60	Murray River	16380
7	Brisbane River	258953	61	Morning Inlet	16042
8	Victoria River	195000	62	Mcarthur River	15167
9	Gilbert River	235142	63	Coleman River	13178
10	Barkly	227658	64	Holroyd River	12867
11	Border Rivers	223062	65	Fitzmaurice River	12426
12	Wiso	199534	66	Tully River	12203
13	Mitchell River	182736	67	Barron River	10616
14	Fitzroy River WA	182723	68	Limmen Bight River	10468
15	Warrego River	147584	69	South Coast	9887
16	Norman River	145726	70	Water Park Creek	9476
17	Mackay	130873	71	Wenlock River	9438
18	Mary River	125981	72	Ross River	9245
19	Leichardt River	124432	73	Mary River NT	8520
20	Nicholson River	123670	74	Pioneer River	8142
21	Moonie River	99034	75	Curtis Island	8095
22	Logan-Albert Rivers	96743	76	Cape Leveque Coast	8048
23	Daly River	94417	77	Onslow Coast	7831
24	Herbert River	81035	78	Pine River	7810
25	Staaten River	74910	79	Archer River	7635
26	Ord River	72425	80	Lyndon-Minilya Rivers	7477
27	Roper River	67704	81	Black River	7288
28	Sandy Desert	65771	82	Daintree River	7197
29	Baffle Creek	65641	83	Maroochy River	6420
30	O'Connell River	54598	84	Mulgrave-Russell River	5654
31	Styx River	52716	85	Calvert River	5615
32	Kolan River	52632	86	Adelaide River	5358
33	Isdell River	52072	87	Jeannie River	4864
34	Todd River	47923	88	Robinson River	4271
35	Haughton River	46183	89	Olive-Pascoe River	4035
36	Settlement Creek	46119	90	Finniss River	3670
37	De Grey River	45199	91	Embley River	3583
38	Boyne River	42072	92	Watson River	3485
39	Burt	40801	93	Ducie River	3416
40	Calliope River	40434	94	Stewart River	2987
41	Shoalwater Creek	38590	95	Rosie River	2754
42	Don River	38369	96	Endeavour River	2610
43	Paroo River	37890	97	Jacky Jacky Creek	2303
44	Finke River	37607	98	Fraser Island	2173
45	Lennard River	36470	99	Mossman River	2140
46	Proserpine River	33734	100	Towns River	2118
47	Noosa River	30682	101	Lockhart River	855
48	Pentecost River	30673	102	Moyle River	684
49	Ashburton River	29322	103	Lake Frome	331
50	Drysdale River	28832	104	Stradbroke Island	141
51	Normanby River	28038	105	Torres Strait Islands	69
52	Fortescue River	27473	106	Jardine River	14
53	Burrum River	24471	107	Gascoyne River	2
54	Port Hedland Coast	22370		**Total**	**11,434,349**

Table 6.3: Ranking of catchments according to beef turnoffs (average of 1992-96)

Rank	Catchment	Cattle no.	Rank	Catchment	Cattle no.
1	Fitzroy River	663911	55	Drysdale River	5554
2	Condamine-Culgoa River	451735	56	Port Hedland Coast	5111
3	Diamantina River	383561	57	Tully River	4574
4	Burdekin River	239659	58	Keep River	4397
5	Burnett River	160870	59	Prince Regent River	4152
6	Border Rivers	133790	60	Plane Creek	4050
7	Flinders River	115030	61	King Edward River	3880
8	Brisbane River	100342	62	Normanby River	3828
9	Logan-Albert Rivers	60117	63	Barron River	3661
10	Barkly River	58577	64	Pine River	3454
11	Wiso	47853	65	Mcarthur River	3172
12	Mary River	40312	66	Morning Inlet	2963
13	Fitzroy River WA	37168	67	Fitzmaurice River	2854
14	Moonie River	35456	68	Mulgrave-Russell River	2719
15	Victoria River	35306	69	Ross River	2389
16	Gilbert River	32488	70	Water Park Creek	2378
17	Warrego River	32375	71	Onslow Coast	2376
18	Mackay	28837	72	Lyndon-Minilya Rivers	2299
19	Leichardt River	28386	73	Maroochy River	2079
20	Mitchell River	27294	74	Limmen Bight River	1988
21	Nicholson River	27146	75	Cape Leveque Coast	1961
22	Norman River	24263	76	Black River	1870
23	Daly River	17726	77	Pioneer River	1809
24	Herbert River	15999	78	Daintree River	1790
25	Ord River	15719	79	Coleman River	1785
26	Sandy Desert	15443	80	Holroyd River	1743
27	Baffle Creek	15337	81	Curtis Island	1603
28	Styx River	13432	82	Mary River NT	1356
29	Roper River	12354	83	Wenlock River	1279
30	Staaten River	12209	84	Archer River	1034
31	O'Connell River	11915	85	Calvert River	988
32	Todd River	11458	86	Adelaide River	853
33	De Grey River	11202	87	Robinson River	743
34	Haughton River	10868	88	Jeannie River	659
35	Isdell River	10359	89	Finniss River	584
36	Kolan River	10304	90	Olive-Pascoe River	547
37	Burt	10219	91	Mossman River	546
38	Shoalwater Creek	9684	92	Fraser Island	537
39	Settlement Creek	9399	93	Embley River	485
40	Ashburton River	9014	94	Watson River	472
41	Finke River	8773	95	Ducie River	463
42	Paroo River	8697	96	Rosie River	462
43	Johnstone River	8692	97	Stewart River	405
44	Boyne River	8401	98	Towns River	356
45	Noosa River	8389	99	Endeavour River	354
46	Don River	8301	100	Jacky Jacky Creek	312
47	Calliope River	8039	101	Lockhart River	116
48	Fortescue River	7467	102	Moyle River	109
49	Lennard River	7258	103	Lake Frome	98
50	Proserpine River	6199	104	Stradbroke Island	56
51	Murray River	6152	105	Gascoyne River	1
52	Pentecost River	5922	106	Torres Strait Islands	0
53	Burrum River	5908	107	Jardine River	0
54	South Coast	5609		**Total**	**3,184,178**

Table 6.4: Ranking of catchments according to beef productivity per unit land area (animals/ha)

Rank	Catchment	Animals/ha	Rank	Catchment	Animals/ha
1	O'Connell River	0.7594	55	Mitchell River	0.0273
2	Noosa River	0.6064	56	Fitzmaurice River	0.0252
3	Plane Creek	0.4184	57	Cape Leveque Coast	0.0248
4	Proserpine River	0.3683	58	Daly River	0.0247
5	Tully River	0.3307	59	Barkly	0.0238
6	Logan-Albert Rivers	0.3197	60	Lennard River	0.0234
7	Murray River	0.3187	61	Isdell River	0.0231
8	Mary River	0.2850	62	Sandy Desert	0.0227
9	Johnstone River	0.2824	63	Fitzroy River WA	0.0226
10	Pioneer River	0.2670	64	Diamantina River	0.0219
11	Kolan River	0.2649	65	Ord River	0.0208
12	Brisbane River	0.2642	66	Wiso	0.0196
13	Maroochy River	0.2527	67	Keep River	0.0190
14	Burnett River	0.2322	68	Lake Frome	0.0175
15	Fitzroy River	0.2092	69	Mackay	0.0163
16	Border Rivers	0.2088	70	Normanby River	0.0159
17	Baffle Creek	0.2085	71	Olive-Pascoe River	0.0157
18	Water Park Creek	0.2083	72	Stewart River	0.0157
19	Shoalwater Creek	0.2083	73	Lockhart River	0.0157
20	Boyne River	0.2070	74	Coleman River	0.0157
21	Calliope River	0.2065	75	Holroyd River	0.0157
22	Curtis Island	0.2055	76	Wenlock River	0.0157
23	Haughton River	0.1939	77	Archer River	0.0157
24	Pine River	0.1877	78	Jeannie River	0.0157
25	Styx River	0.1876	79	Ducie River	0.0157
26	Burrum River	0.1701	80	Endeavour River	0.0157
27	Barron River	0.1685	81	Jacky Jacky Creek	0.0157
28	South Coast	0.1398	82	Embley River	0.0156
29	Daintree River	0.1343	83	Watson River	0.0153
30	Don River	0.1332	84	Burt	0.0141
31	Mossman River	0.1297	85	Roper River	0.0131
32	Moonie River	0.1270	86	Prince Regent River	0.0121
33	Herbert River	0.1177	87	Todd River	0.0121
34	Mulgrave-Russell River	0.1171	88	Port Hedland Coast	0.0118
35	Black River	0.1086	89	Paroo River	0.0117
36	Ross River	0.1060	90	Finke River	0.0106
37	Condamine-Culgoa River	0.0923	91	Pentecost River	0.0103
38	Fraser Island	0.0921	92	Drysdale River	0.0102
39	Burdekin River	0.0906	93	King Edward River	0.0101
40	Stradbroke Island	0.0878	94	De Grey River	0.0099
41	Gilbert River	0.0538	95	Mcarthur River	0.0086
42	Flinders River	0.0522	96	Fortescue River	0.0083
43	Morning Inlet	0.0443	97	Ashburton River	0.0074
44	Leichardt River	0.0386	98	Gascoyne River	0.0074
45	Staaten River	0.0353	99	Lyndon-Minilya Rivers	0.0074
46	Victoria River	0.0310	100	Limmen Bight River	0.0071
47	Moyle River	0.0308	101	Onslow Coast	0.0069
48	Mary River NT	0.0308	102	Calvert River	0.0063
49	Adelaide River	0.0308	103	Robinson River	0.0062
50	Finniss River	0.0308	104	Rosie River	0.0059
51	Nicholson River	0.0297	105	Towns River	0.0059
52	Norman River	0.0297	106	Jardine River	0.0044
53	Warrego River	0.0277	107	Torres Strait Islands	0.0044
54	Settlement Creek	0.0273			

Table 6.5: Ranking of catchments according to percentage of land grazed

Rank	Catchment	% Grazed	Rank	Catchment	% Grazed
1	Morning Inlet	100.0	55	Coleman River	64.1
2	Drysdale River	99.5	56	Towns River	64.0
3	King Edward River	98.6	57	Roper River	62.8
4	Paroo River	98.6	58	Olive-Pascoe River	60.9
5	Prince Regent River	98.3	59	Robinson River	57.4
6	Isdell River	98.2	60	Ord River	56.9
7	Lake Frome	98.1	61	Fortescue River	55.3
8	Flinders River	97.8	62	South Coast	55.1
9	Norman River	97.1	63	Haughton River	54.8
10	Pentecost River	96.2	64	Moonie River	54.5
11	Settlement Creek	96.1	65	Shoalwater Creek	51.8
12	Leichardt River	95.5	66	Jacky Jacky Creek	51.7
13	Warrego River	94.9	67	Onslow Coast	51.5
14	Burdekin River	94.8	68	Murray River	49.3
15	Gilbert River	94.0	69	Embley River	49.2
16	Lennard River	93.7	70	Watson River	48.4
17	Mitchell River	93.6	71	Mary River	46.5
18	Styx River	93.5	72	Ashburton River	46.0
19	Mcarthur River	90.9	73	Border Rivers	45.3
20	Limmen Bight River	90.6	74	Port Hedland Coast	43.6
21	Calliope River	89.7	75	Fitzmaurice River	43.5
22	Diamantina River	88.2	76	Burrum River	42.1
23	Calvert River	86.4	77	Logan-Albert Rivers	41.0
24	Jeannie River	86.4	78	Wiso	39.7
25	Rosie River	84.3	79	Proserpine River	36.6
26	Boyne River	82.4	80	Archer River	34.9
27	Staaten River	81.7	81	Mary River NT	32.9
28	Don River	81.4	82	Brisbane River	32.0
29	Torres Strait Islands	81.3	83	Ducie River	31.9
30	Endeavour River	80.4	84	O'Connell River	31.0
31	Keep River	80.3	85	Mossman River	31.0
32	Wenlock River	80.3	86	Johnstone River	30.5
33	Holroyd River	79.6	87	Barron River	29.5
34	Baffle Creek	78.9	88	Daintree River	28.3
35	Finke River	78.7	89	Pine River	28.0
36	Nicholson River	78.2	90	Water Park Creek	27.8
37	Fitzroy River WA	77.9	91	Noosa River	26.3
38	Curtis Island	77.4	92	Mulgrave-Russell River	24.2
39	Fitzroy River	76.7	93	Tully River	23.2
40	Condamine-Culgoa River	76.4	94	Adelaide River	22.0
41	Victoria River	74.3	95	Pioneer River	19.3
42	Barkly	73.5	96	Lockhart River	19.0
43	Burnett River	72.0	97	Mackay	17.9
44	Normanby River	71.7	98	Maroochy River	17.0
45	Stewart River	70.7	99	Plane Creek	16.6
46	Herbert River	70.6	100	Cape Leveque Coast	15.7
47	Daly River	69.4	101	Fraser Island	14.3
48	Kolan River	68.1	102	Finniss River	11.4
49	De Grey River	66.7	103	Sandy Desert	6.3
50	Todd River	66.0	104	Stradbroke Island	3.3
51	Ross River	65.1	105	Moyle River	2.6
52	Burt	65.0	106	Jardine River	<1
53	Lyndon-Minilya Rivers	64.9	107	Gascoyne River	<1
54	Black River	64.2			

Table 6.6: Overall ranking of beef catchments according to averaged rank

Rank	Catchment	Average	Rank	Catchment	Average
1	Fitzroy River	14	55	De Grey River	53.25
2	Burdekin River	15	56	South Coast	53.25
3	Flinders River	15.5	57	Curtis Island	54
4	Burnett River	17	58	Sandy Desert	54.75
5	Gilbert River	20.25	59	Tully River	55.25
6	Condamine-Culgoa River	20.75	60	Plane Creek	55.25
7	Diamantina River	22.75	61	Normanby River	56.75
8	Leichardt River	23.5	62	Ross River	57
9	Warrego River	24.5	63	Mcarthur River	60.25
10	Norman River	24.75	64	Barron River	61
11	Styx River	25.5	65	Black River	61.5
12	Mitchell River	26.25	66	Water Park Creek	62
13	Border Rivers	26.5	67	Holroyd River	63.5
14	Baffle Creek	26.75	68	Pine River	63.75
15	Mary River	27.25	69	Pioneer River	64
16	Brisbane River	27.25	70	Fortescue River	64.25
17	Victoria River	27.5	71	Ashburton River	64.5
18	Logan-Albert Rivers	28.5	72	Limmen Bight River	65.5
19	Barkly	30.25	73	Wenlock River	65.5
20	Staaten River	31.75	74	Fitzmaurice River	65.75
21	Fitzroy River WA	31.75	75	Maroochy River	66.75
22	Herbert River	31.75	76	Port Hedland Coast	68
23	Kolan River	31.75	77	Jeannie River	68.25
24	Boyne River	32	78	Coleman River	68.75
25	Nicholson River	32	79	Daintree River	69.25
26	Calliope River	32.25	80	Mulgrave-Russell River	69.5
27	Moonie River	32.75	81	Lake Frome	70.25
28	Isdell River	33.75	82	Mary River NT	71
29	Settlement Creek	35	83	Calvert River	73.75
30	Don River	36.5	84	Endeavour River	75
31	O'Connell River	36.5	85	Lyndon-Minilya Rivers	76
32	Daly River	37.75	86	Mossman River	76.5
33	Haughton River	38.75	87	Stewart River	76.75
34	Shoalwater Creek	40.75	88	Cape Leveque Coast	77
35	Wiso	41.75	89	Olive-Pascoe River	77.25
36	Lennard River	42.5	90	Adelaide River	78.75
37	Morning Inlet	42.75	91	Onslow Coast	79
38	Ord River	44	92	Rosie River	80
39	Paroo River	44.5	93	Archer River	80.5
40	Proserpine River	44.75	94	Fraser Island	82.25
41	Noosa River	46.25	95	Finniss River	82.75
42	Murray River	46.5	96	Embley River	83.75
43	Johnstone River	49	97	Robinson River	84.25
44	Roper River	49.5	98	Watson River	84.75
45	Drysdale River	49.75	99	Jacky Jacky Creek	86
46	Pentecost River	50.25	100	Torres Strait Islands	86.75
47	Mackay	50.25	101	Ducie River	87.75
48	Todd River	50.75	102	Stradbroke Island	88
49	Prince Regent River	51.25	103	Moyle River	89
50	Burrum River	52	104	Towns River	89.75
51	Finke River	52.5	105	Lockhart River	92.75
52	Burt	53	106	Gascoyne River	104.25
53	King Edward River	53.25	107	Jardine River	106.25
54	Keep River	53.25			

6.4 Evaluation of short-listed catchments

In the final ranking step, the top 30 ranked catchments from step 1 were compared to the top 30 ranked for relevance to the beef industry in step 2. A total of twelve catchments were found to be represented within both ranking lists (in order of intrinsic vulnerability):

1. Mitchell
2. Victoria
3. Ord
4. Fitzroy (QLD)
5. Burdekin
6. Isdell
7. Brisbane
8. Gilbert
9. Fitzroy (WA)
10. Burnett
11. Flinders
12. Condamine-Culgoa
13. Leichardt

The Ord was included in this short-list although it only ranks 38th in terms of industry relevance due to its high intrinsic vulnerability and because it is the only catchment in NA with whole of catchment sediment export information.

This list was further narrowed down by means of expert assessment by matching the above catchments against a set of predetermined criteria. These were:

Biophysical assessment
- Assessment of spatial variation of erosion susceptibility and actual occurrence
- Important off-site impacts - riparian zones, wetlands, freshwater and marine systems
- Representativeness of catchment to northern Australian landscapes

Producer/community issues
- Assessment of relevance of catchment to the beef industry
- Producer awareness of erosion problems and off-site effects
- Assessment of community/producer activities and involvement in catchment management
- Potential channels of communication.
- Socio-economic background - property sizes, land tenure, off-farm income, debt levels

Resource and research information
- Available land resource information - land systems, climate, geology, soils, vegetation
- Available water resources information - gauged sites, water quality monitoring
- Past research
- On-going and planned research

Existing infrastructure
- Research infrastructure - research centres, staff numbers
- Existing extension infrastructure
- Accessibility - wet season, remoteness

Particular attention at this stage was paid to the perceived level of community/producer awareness and the likelihood of successful transfer of research outcomes to producers, as well as the level of current and past research activity and regional importance of the catchment. Matching the 13 catchments against the above criteria resulted in a preliminary short-list containing 6 catchments:

Brisbane, Burdekin, Burnett, Fitzroy (QLD), Ord and Victoria.

The Flinders, Gilbert, Isdell, Leichardt and Mitchell River catchments were excluded mainly on the grounds of lack of resource information and remoteness with respect to research and

extension facilities. The Condamine-Culgoa, was excluded as being insufficiently representative of Northern Australia.

The remaining list was further shortened during the 2nd workshop by excluding the Brisbane River catchment on the grounds that it was too strongly urbanised to be truly representative, leaving the following final 5 catchments for further detailed scrutiny in the following sections:

Burdekin, Burnett, Fitzroy (QLD), Ord, Victoria.

These catchments were assessed in greater detail against the above list of criteria before proceeding to a final ranking.

6.4.1 Burdekin

Biophysical assessment

Assessment of spatial variation of erosion susceptibility
An overview of the distribution and magnitude of erosion indices for the Burdekin catchment is provided in Fig. 6.11, together with summary statistics on key biophysical characteristics. Total discharge is highest of all short-listed catchments, in part caused by high rainfall in the ranges along the eastern fringe of the catchment. Interannual variability of rainfall is also highest. Erosion indices (Tab. 8.5A and 8.5B) show a high degree of variation, in part directly related to higher rainfall and greater relief in the eastern portions, but also affected by geology and soils. Clearly discernible are the potentially more vulnerable landscapes associated with sedimentary rocks in the central part of the catchment, as opposed to more stable, flat tertiary landscapes showing generally lower indices. In summary, inherent susceptibility to erosion varies across the region with geology, soils and slope. For example, basalt landscapes have relatively stable, uniform clays soils on level plains while sedimentary landscapes have relatively unstable solodic soils on gently to steeply inclined slopes.

Landscapes in the catchment are typically eucalypt woodland and all are vulnerable to land degradation from overgrazing, woody weed invasion, and/or excessive tree clearing. Sedimentary rocks and Cainozoic sediments provide the most extensive landscapes, covering 50% of the upper catchment. The solodic and red and yellow earth soils on these landscapes are inherently the most vulnerable to degradation. Red duplex soils and loams on granodiorite, and red-brown earths on alluvium (16% of area), are moderately susceptible, while basalt landscapes (euchrozems, clays) (13% of area) are relatively resistant to degradation. With the exception of the Balfes Creek area, there is relatively little clearing of eucalypt woodland in the Upper Burdekin catchment, whereas more extensive areas have been cleared in the Belyando sub-catchment, both for cropping and grazing.

Actual occurrence of erosion in the upper Burdekin was assessed by De Corte *et al.* (1994), Mortiss (1995) and more systematically, during the land resource survey by Rogers *et al.* (1998). The latter authors found that about 60% of assessment sites showed some form and extent of erosion, with sheet erosion occurring at 34% of sites, scalding at 12% of sites and gully erosion at 12% of sites. This data does not necessarily imply that the over-all condition of all these sites was poor (see below). The lowest incidence of erosion was on basalt landscapes (25% of sites) and the highest incidence on sedimentary landscapes (70% of sites).

Tothill and Gillies (1992) estimate that approx. 40 % of the Black Speargrass communities were in condition A (sustainable), 40 % in condition B (deteriorating) and 20 % in condition C (degraded). Somewhat in contrast De Corte *et al.* (1994) found that based on indices of pasture composition and basal area, about 20% of assessment sites were in poor condition, 25% in fair condition and the remaining 55% in good condition. Following the recent drought, the proportions of sites in poor and fair condition have probably increased significantly.

Important off-site impacts
Major areas susceptible to off-site impacts include extended lengths of riparian zones, freshwater systems (eg. permanent waterholes in major tributaries and the Burdekin itself; Burdekin Dam) and the Great Barrier Reef Lagoon.

Riparian zones in the Upper Burdekin catchment show a large range in condition, with about 40% of sites showing some signs of erosion and low grass basal area and about 20% of sites being invaded by exotic weeds. These effects are largely due to direct grazing impacts on the riparian areas but are likely to be exacerbated by sediment and nutrient runoff from upper parts of the catena.

Little information of grazing impacts on freshwater systems is available, but the Australian Centre for Tropical Freshwater Research (ACTFR) at JCU has been monitoring sites, streams and waterholes within the 230,000 ha Army's Field Training area within the northern part of the catchment. Also, the ACTFR is monitoring the impact of the riparian fencing project on aquatic habitat in the western part of the catchment (refer to proformas Nos. 33 and 34). Information is also scarce on the condition of wetlands, of which approx. 15 are classified as of national importance (Blackley *et al.*, 1996) and some of which being monitored by QDoE.

With respect to water quality for users downstream, there is increasing concern over the sediment input into the Burdekin dam, as well as the generally high sediment load in water sourced by the Burdekin Irrigation Area. As the dam intercepts most coarse sediment from the northern part of the catchment, it is assumed that the coarse sediment in irrigation water is due to runoff from the grazing lands in the southern part of the catchment, ie, mainly from the Bogie and Bowen Rivers which enter the Burdekin River below the dam.

Probably the most decisive off-site impact from the Burdekin is its sediment and nutrient discharge into the Great Barrier Reef Lagoon and depending on the information source, the Burdekin is ranked as the catchment with the greatest individual sediment delivery to the GBR lagoon (Belperio, 1978; Rayment and Neil, 1997; Mitchell and Furnas, 1997). Belperio (1978) estimated average sediment discharge rates of 4.35 t x 10^6, with a range of 0.09 t x 10^6 in drought years to 25.8 t x 10^6 in flood years. At this stage it seems that the outer reef has remained unaffected by major sediment plumes, but certainly near shore and estuarine systems of the Burdekin mouth are being affected by the high sediment loads (Brunskill, Brodie, pers. comm.). Interestingly, Fleming *et al.* (1981) in their study assessing the ecological impacts of the Burdekin Dam point out that little information was available to assess sources of sediments in the reaches above the dam site.

Representativeness of the catchment to northern Australia
The Burdekin catchment contains the variety of landscapes and climatic settings typical of northern Australian grazing lands. Grazing is the major land use and is practically the only land use away from the coastal Burdekin Irrigation Area. There is a low degree of regulation of flow, particularly in the upper part of the catchment. All of the northern and western parts of the upper catchment flows eventually into the Burdekin dam, with only a couple of small weirs upstream of the dam. The southern section of the upper catchment either feeds into the

Burdekin dam or enters the main Burdekin channel just below the dam. Thus, distinguishing sediment and nutrient inputs from the grazing lands versus other land uses could be relatively easy.

Producer/community issues

Relevance of catchment to the beef industry
The Burdekin catchments is one of the most important beef producing catchments in NA, in particular on the basis of its total cattle numbers (average 1,116,800 head) and high turnoff (239,659, 92-96 statistics), where it ranks 3rd and 4th, respectively (refer to Tab. 6.2 and 6.3). Due to the lower inherent productivity of extensive areas of the catchments, stock densities are lower (0.091), with the catchment ranked 39th in this respect. With the exception of the irrigation area in the Lower Burdekin, land use is predominantly pastoralism, with approx. 95 % of the catchment grazed.

Producer awareness of erosion problems and off-site effects
There appears to be moderate awareness of erosion problems and low-moderate awareness of off-site effects. This subjective assessment is based on the degree of interaction of producers with peers (eg, group activities), extension agencies, "landcare" activities, R&D in grazing management, resource/business planning, and sub-catchment/catchment planning. The extent of awareness is probably much greater in the northern and western parts of the upper catchment, compared with the southern part of the catchment.

Assessment of community/producer activities and involvement in catchment management
Dalrymple Shire dominates the northern and central parts of the upper Burdekin catchment and within this shire, about 75% of the 200 "full-time" beef producers are associated with a landcare group. There are 14 well-established landcare groups, at least half of which are beginning to address issues of grazing management, strategic weed management, and business planning. Soil erosion has been identified as one of three major sustainability issues (eg Balfes Creek Catchment Group; Seventy Mile Range Catchment Group; see also Mortiss, 1995).

Bowen Shire dominates the southern part of the Burdekin upper catchment. Less than 15-20% of beef producers are associated with a landcare group. There are only 2 well-established groups. About half of Belyando Shire is within the Burdekin catchment grazing lands, where there are 4 active landcare groups, focussed mainly on management of weeds. Overall, awareness of sustainability issues in general and soil erosion specifically is lower than within the Dalrymple Shire.

An overview of current or planned NHT funded projects as an indicator of community and producer activities is given in Tab.6.7. A broad range of projects have been submitted, with the Riparian Zone Management Project, that is spread across several NHT programs, being the most important and relevant project. Currently the Burdekin catchment is also entering a stage of strategy development funded by the Natural Heritage Trust. This will involve extensive community consultation on resource management and sustainability issues and is likely to further increase levels of awareness.

Potential channels of communication
The catchment can be characterised as having an active extension service, and there are a number of initiatives sponsored by QDPI and activities linked to major producer driven NHT projects, some of which are listed below:

- QDPI FutureProfit workshop series
- QDPI/MLA SmartManager workshop series

- QMLA pasture monitoring project
- QMLA BeefPlan project
- NHT riparian fencing project
- NHT project on developing a resource management strategy for the Burdekin dry tropics
- MLA grazing management R&D projects
- QDPI pasture management workshops
- QDPI stocking rate demonstrations
- Evolving network of land-holder groups

Table 6.7: Overview of current and planned NHT funded projects within the Burdekin catchment

Project	Lead organization	Objective	Total project cost
Bushcare			
Riparian Zone Management - Central Upper Burdekin Catchment	Dalrymple Shire catchment	Not given	$974,250
National Landcare Program			
A regional Strategy for the Grazing Lands of the Burdekin Dry Tropics	Queensland Department of Primary Industries	To develop and implement a strategic plan for resource management, nature conservation and biodiversity in the grazing lands of the Burdekin dry tropics	$147,990
Burdekin Floodplain Integrated Management: Developing a Sub-regional Strategy	Lower Burdekin Landcare Association, JCU and the ACTFR	To develop a prioritised plan of activities to establish ongoing integrated management of the Burdekin floodplain	$59,880
Dalrymple Landcare Project Coordination	Dalrymple Landcare Committee	Employment of a full-time co-ordinator to work with the Dalrymple Landcare Committee	$117,910
Property Management Planning in the Bowen/ Burdekin/ Whitsunday Grazing Lands	Queensland Department of Primary Industries	The extension of employment for an officer to develop and deliver property management planning services to producers in the Bowen, Burdekin and Whitsunday Shires of North Queensland	$108,840
Riparian Zone Management - Central Upper Burdekin Catchment	Dalrymple Shire Council	To improve the biodiversity of the riparian zone over 2.51 M ha of the Upper Burdekin Catchment by fencing the double frontage of major watercourses in the area	$1,073,740
National Rivercare Program			
Riparian Zone Management - Central Upper Burdekin Catchment	Dalrymple Shire Council	To improve the biodiversity of the riparian zone over 2.51 M ha of the Upper Burdekin Catchment by fencing the double frontage of major watercourses in the area	$71,575

Information provided by NHT, current May 1998

Socio-economic background
There are about 500 full-time beef producers in the Burdekin catchment, including part-time and smallholder producers. Properties vary in size from 8000 to 80,000 ha, carrying from 1000 to 10,000 head. Hinton (1993) estimated from a survey of Dalrymple cattle properties that a minimum carrying capacity of about 2000 adult equivalents was required to remain viable in the short to medium term. With current cattle prices and continuing drought, this minimum carrying capacity may now be closer to 2500 or 3000 adult equivalents.

Average rate of return to total resources is very low, with values varying between -1 to 3% (Hinton 1993). At the same time, average debt is about $300,000 and average equity about 80% per enterprise. Overall, not many opportunities for economic activities exist outside the grazing industry and off-farm income is generally low. One of the few opportunities lies in eco-tourism, with a number of properties engaged in this sector. Across the catchment, land tenure is mostly leasehold.

Resource and research information

Available land resource information
An overview of existing land resource information is given in Tab. 6.8. A fair amount of information exists, in particular for the Upper Burdekin catchment, where the recent land resource study conducted by Rogers *et al.* (1998) has provided some useful quantitative soils and land condition data, which would prove to be extremely valuable for future catchment modeling work.

In addition, a number of minor, very localised soil surveys have been conducted, mainly in the Lower Burdekin with the objective of assessing irrigation potential.

Table 6.8: Overview of existing land resource information in the Burdekin catchment

Land systems	Geology	Soils	Vegetation and land cover	Land capability, resource management
• General report on the Lands of the Leichhardt-Gilbert Area, Qld (CSIRO 1964, 1:1,000,000) • Survey of the Townsville - Bowen region (CSIRO 1953, 1:250,000) • Lands of the Nogoa-Belyando Area, Qld (CSIRO 1967, 1:500,000)	• 1:100,000 - small area • 1:250,000 - whole catchment	• Atlas of Australian Soils • Land resources of the Dalrymple Shire (Rogers *et al.* 1997, 1:250,000) • Soil fertility of Central and NE Queensland grazing lands (Ahern *et al.* 1994), 1:1,000,000) • Soils and land use potential: Lower Burdekin valley (Hubble 1953) • Soils of the Burdekin - Townsville region (Isbell and Murtha 1970, 1:1,000,000) • Land resource description and evaluation in the Desert Uplands (Lakes Galilee and Buchanan area) (1:100,000, Lorimer 1998)	• Vegetation survey of Brigalow North (Thompson undated; 1:100,000) • 1991 Landcover and vegetation density maps with property boundaries, roads and place names (Qld Statewide landcover and trees study; 1:100,000 and 1:250,000) • Vegetation survey of the Desert Uplands (1:250,00) (In progress)	• Agricultural land resources and management, Mackay region (Dawson and Turner 1980) • Central Highlands Field manual (Thwaites, undated) • Land capability study of the Northern Burdekin Region (Kent and Shields 1984) • Land suitability of the Collinsville - Nebo Moranbah regions (Shields 1984) • Pasture lands of northern Australia (Tothill and Gillies, 1992)

Available water resource information
There are 50 gauging stations within the Burdekin Catchment, 31 of which are still operating. At 10 of these sites, pluvio-graph data is available while water quality data is available from seven sites (QDNR, 1997). There are four weirs within the catchment and two dams ranging from the Eungella in the upper reaches of the Bowen river basin to the Burdekin Falls Dam, which controls the discharge from 90 % of the catchment.

Water quality has been mainly assessed with respect to the needs of irrigation in the Lower Burdekin. Electrical conductivity is showing slight upwards trends for the period 1961 - 1996 (Clarke, 1997), associated with a generally deteriorating quality of water from Burdekin Falls Dam. This could be indicative of increasing sediment loads with a high proportion of fines originating from the drought affected and in parts heavily degraded grazing lands within Dalrymple Shire. Irrigation practices have been leading to rising water tables, and the more intensive land use (sugar cane, horticulture) in the irrigated areas has lead to increases in pesticide and herbicide contamination of surface and groundwaters through discharge of contaminated waters from farms to Burdekin and Haughton Rivers (Clarke, 1997).

Past research and ongoing research
Due to its proximity to Townsville with presence of a number of major R& D providers, the Upper Burdekin catchment has traditionally been a focus for a multitude of research activities. In fact, several key sites established near Charters Towers (eg ECOSSAT sites Cardigan, Hillgrove) and further west (Pentland) have harboured major research activities, greatly contributing to our current understanding of plot scale processes with respect to grazing management and sediment and runoff generation (eg, Williams and Bonell, 1988; McIvor *et al.*, 1995; Scanlan *et al.*, 1996a, 1996b). Aspects of hydrology and dryland salinity have also received a fair amount of attention, with past work ranging from plot (Williams *et al.*, 1997) to catchment scale (Fleming *et al.*, 1981; Bui *et al.*, 1996). Ongoing work within the framework of LWRRDC's National Dryland Salinity Program is focussed on the Balfes Creek sub-catchment (for details refer to research proformas No. 7, 36; Appendix 8.4).

Presently, a number of important NAP3 funded projects related to grazing management, control of woody weeds and assessment of dryland acidification have major sites located in the Upper Burdekin catchment (proformas Nos. 18, 19, 20, 23). In addition, some of the only ongoing current hillslope to sub-catchment scale work in grazed catchments of NA is located in the Upper Burdekin, at this stage focussing more on combined grazing/military land use impacts on land condition and risks of sediment and nutrient delivery to freshwater bodies (proformas No. 3, 5, 15, 32). Linkage of the proposed research components to this work would provide opportunities to reduce project costs and add-value to the ongoing work.

The Australian Institute of Marine Science (AIMS), in collaboration with the CRC Reef Research Centre and the Great Barrier Reef Marine Park Authority (GBRMPA), are studying human impacts (agriculture, tourism, urban development) on coastal marine ecology, including mangroves, fringing reefs, seagrass beds and coastal fisheries. Some work is conducted in the Burdekin River region of the Great Barrier reef (GBR) with other studies in the Herbert River region and Cairns region. AIMS is also attempting to measure the quantity of soil and nutrients being washed down the Burdekin, and other rivers (refer to proforma No. 30), into the GBR lagoon, as well as the assimilation of these nutrients into reef ecosystems. In terms of off-site impact work of relevance to the Burdekin, linkages to work being carried out by AIMS (research proformas No. 28, 30) could provide a valuable means of linking the critical research components identified in section 5.2 to off-site aspects of sediment and nutrient delivery to marine ecosystems.

Existing infrastructure

Research infrastructure
The Burdekin has in the past been and continues to be well serviced through the scientific institutions concentrated in Townsville (CSIRO Davies Laboratory, JCU, AIMS and GBRMPA) and Charters Towers (QDPI Grazing Management Unit, QDNR Tropical Weeds Center). JCU also hosts or is partner to three CRC's relevant to work in the Burdekin: CRC Sustainable Development of Tropical Savannas, CRC Sustainable Sugar Production, CRC Reef Research. Approximate staff numbers for the various research providers are listed below:

- CSIRO Tropical Agriculture
  - sustainable land management (14 people)
- CSIRO Land and Water
  - sustainable land management, hydrology and modelling (10)
- QDPI Charters Towers
  - grazing land management (5)
- QDNR Tropical Weeds, Charters Towers
  - exotic weed ecology and chemical/mechanical control (8)
- James Cook University Australian Centre for Tropical Freshwater Research
  - riparian zone and aquatic systems management (15)
- Australian Institute of Marine Science
  - human impacts on coastal marine ecology (16)
- James Cook University Tropical Environment Studies and Geography
  - remote sensing of savanna lands (2)
- CSIRO Mathematics and Statistics
  - remote sensing time trend analyses to detect land condition change at broad scales (2)
- Queensland University Earth Sciences
  - sedimentology of the Burdekin River (2)
- CRC for Tropical Savannas
  - Desert Uplands Regional Study (10)

Extension infrastructure

- QDPI Charters Towers
  - grazing land management (3)
- QDPI Ayr/Bowen
  - grazing land management (3)
- QDPI/QDNR Clermont
  - grazing land management (2)
- QDNR Tropical Weeds, Charters Towers
  - exotic weed management (2)

Accessibility
All parts of the catchment are highly accessible for most of the year, with the Flinders Highway crossing in east-west direction and the Gregory Developmental Road traversing in north-south direction. For some periods during the wet season, upper parts of the catchment will have moderate accessibility, and major highways are only likely to be interrupted during major flooding events. The mobile phone network is limited to the main transport axes and air transport is restricted to small aircraft.

6.4.2 Burnett

Biophysical Assessment

Assessment of spatial variation of erosion susceptibility
The region is a complex mixture of metamorphic, igneous and sedimentary rocks. The west to east sequence of outcrops of these rocks influences soil distribution more dramatically than their sequence from north to south. The dominant north-west to south-east lineation of the different rock types is interrupted in parts by outcrops of large areas of granitic rocks, characterised by either steep scarps or low, rolling, gently sloping landscapes. Consolidated sediments occupy much smaller areas and were deposited in well defined basins. Basalts are prominent in the south with occurrences further north. Recent alluvial deposits cover only small parts of the district along major creeks and rivers.

An overview of the distribution and magnitude of erosion indices is provided in Fig. 6.12, together with summary catchment statistics. In general, the indices for potential sheet /rill erosion were moderate to high throughout the catchment (the anomalies visible in the lower part of Fig. 6.12a result from data anomalies in the ERIN vegetation coverages and are presumably classification artefacts). The potential for gully/channel is shown to be highest in the north-east higher rainfall and relief areas of the catchment. In a broad sense, the catchment can be divided into two regions of differing susceptibility based on either older geological formations (largely granitic in nature), or more recent tertiary deposits which have developed richer soils which are commonly used for cropping. The dominant pasture community is Black Speargrass (Tothill and Gillies, 1992), which was assessed to be 20 % in condition A, 60% in condition B and 20 % in condition C.

The vegetation communities are dominated by Eucalyptus species which account for approximately 80 % of the area while 'softwood scrub' species as closed forests and scrubs account for 10 %, brigalow and associated community 6 per cent and miscellaneous communities 4 % (Vandersee and Kent, 1983). The four major groups recorded were -
(a) Eucalypt woodland to open forest
(b) closed forest and scrubs
(c) brigalow and associated communities
(d) miscellaneous communities.

Important off-site impacts
The major off-site effects of degradation in the catchment are localised marine disturbances, which mainly affect coastal fisheries. The Burnett is estimated to be the third most important catchment delivering sediment to the GBR lagoon (Rayment and Neil, 1997), although during some events, it might be difficult to separate the impact of the Burnett from that of the Fitzroy (Fleming, pers. comm.).

The river is dammed for either irrigation water or urban use. The major regional city, Bundaberg, partially depends on the river storage for its urban supply. This urban storage occasionally suffers from blue-green algal outbreak which requires expensive water treatment. Small district centres such as Kingaroy, Gayndah and Monto depend on local weirs for their urban water supply and again can suffer from blue-green algal outbreak. While the WAMP for the Burnett Catchment is not yet completed, there is a general feeling that the water resources of the Burnett are heavily committed and that in drought times such as are presently occurring, insufficient water is available for the demands, particularly irrigation, that are placed on it.

Representativeness of the catchment to northern Australia
The catchment is generally more developed than the majority of Northern Australian catchments, with numerous population centres and a diverse range of land uses. Although extensive grazing is the major land use within the catchment, other intensive industries have more economic impact. The Burnett Catchment has less area of erodable sedimentary deposits than many other Northern Australian catchments, therefore the extensive areas of heavily gullied 'badlands' that occur in some of the catchments are generally not a common feature of the Burnett Catchment. Except for the absence of this geological formation, the catchment is representative of the Northern Australian situation.

Producer/Community Issues

Relevance of the catchment to the beef industry
The Burnett catchment has approx. 558,000 head in the catchment, the fifth highest cattle population by catchment in Queensland. The cattle density is also relatively high, at 0.23 head/ha. Cattle are evenly spread throughout the catchment although areas of the southern part of the catchment tend to be dominated by cropping (Kingaroy). Grazing comprises 72 % of the catchment land use. Sugar cane production is concentrated around Bundaberg.

The cattle enterprises tend to be family units of moderate to large property size, although a number of smaller lot feeding operations occur within the catchment. One meat works operation (Murgon) is contained within the catchment. Cattle type is predominantly *Bos indicus*, representative of most of Northern Australia.

Producer awareness of erosion problems and off-site effects
There is a high level of producer awareness of land degradation problems in the catchment, due to a long history of DPI involvement in the catchment. Degradation issues commonly recognised include pasture rundown with associated weed invasion, woody weeds, soil erosion, gully erosion, and salinity. Extensive salinity studies have been carried out in cropping and grazing lands in the South Burnett area.

Offsite consequences are well recognised, particularly siltation of the river system, leading to reduced water supplies, and marine outflow affecting local fisheries. There is a small localised active fishing industry based on Bundaberg at the mouth of the Burnett River which regularly targets land management issues affecting the industry.

Assessment of community/producer activities and involvement in catchment management
The catchment has been targeted for major landcare and ICM initiatives. Nineteen landcare groups occur within the catchment, with four groups being inactive. Most of the remaining groups are very active, but are estimated to only represent approximately 10% of the community. The landcare groups are spread throughout the catchment and all areas are represented. These landcare groups currently have a number of NHT Projects underway within the catchment, covering revegetation, Waterwise projects, weed control trials, riverine improvement works and erosion control projects (Tab. 6.9). In addition, the catchment has been targeted for formation of integrated catchment management. The Burnett Catchment Care Association overviews the operation of the total catchment, and has four subsidiary sub-catchment care groups dealing with the North, Central, South and Coastal Burnett sub-catchments. These groups also have a number of active projects occurring within the catchment.

Producer groups are also active within the catchment, with active UGA and CU committees. In conjunction with agencies, these groups have obtained industry funding for a number of

initiatives, including producer demonstration sites and pasture monitoring trials. The coastal section of the catchment has been extensively studied and the findings are contained in a series of working papers produced by the *Wide Bay 2020 Regional Growth Management Framework* (February 1997). These working papers cover people and settlement, regional economy, and natural resources.

Table 6.9: Overview of current and planned NHT funded projects within the Burnett catchment

Project	Lead organization	Objective	Total project cost
Bushcare			
Barambah - Burnett Bush Botanical Garden (Project not yet certain)	Cherbourg Community Council	To build educational botanical gardens in highland and lowland locations	$165 000
National Landcare Program			
Burnett Valley Resources Inventory and Management Plan for the Burnett Catchment	Burnett Catchment Care Association Inc.	The project involves a search for and collation of existing information for a whole of Burnett Valley Resource Inventory, and the subsequent development of a management plan incorporating all relevant environmental and industry issues	$110,600
Integrated Land Management North and Central Burnett	Creeping Lantana Action Group/North Burnett Landcare Group	Develop and publicise an integrated package of management options that land managers can put in place to control creeping lantana	$215,360
South Burnett Landcare Project Officer	South Burnett Landcare Project Committee	To employ a project officer to assess and collate information on, and assist and support landcare groups in relation to, salinity, sustainable land use and community awareness	$102,757
Waterwatch			
South Burnett Waterwatch Program	South Burnett Community Training Centre Inc.	To assist local groups develop an understanding of the water quality of the surrounding creeks, rivers and Gordonbrook catchment as they affect various users and the natural riparian corridors	$40,500

Information provided by NHT, current May 1998

Potential channels of communication

There are a number of active channels of communication within the catchment, both agency driven and producer driven. There is an active South East Queensland Research Committee which addresses issues within the catchment, as well as consultative committees to agencies active within the catchment. The QDPI has established a network of communication within the catchment with newsletters to producer groups.

Socio-economic background

The majority of the catchment is freehold, although extensive areas of leasehold occur in the northern portion of the catchment. Property size is variable, ranging from 'hobby farms' to

major commercial properties. However, most of the properties are single family enterprises ranging in size from approximately 1,000 ha to 10,000 ha with an average property size of approximately 4,800 ha (*Beef Production Comparative Analysis 1991-92, Southern Speargrass,* MRC Consultancy Taylor/Byrne Agribusiness). Total carrying capacity (AE) range from 400 to 2,300 head with the average being approximately 1,100. Debt levels are continuing to increase, with some 15 % of producers having difficulties servicing their debt level (QRAS, 1996). With the recent severe prolonged droughts in the catchment, many properties are under economic pressure and off-farm income has become a more important component to the overall enterprise. Debt levels are variable, with many older established properties having operating debts only. Some of the newer developing properties have considerable debt levels.

Resource and Research Information

Available land resource information

The whole of the Burnett Catchment has been surveyed and land resource assessment maps are available (see Tab. 6.10). Some of this information is currently in draft form. The land resource assessments have been carried out at land system scale although more detailed information is available for a number of corridor areas along the main river channels. Vegetation monitoring has also been carried out through much of the catchment and major communities have been identified.

Table 6.10: Overview of existing land resource information in the Burnett catchment

Land systems	Geology	Soils	Vegetation and land cover	Land capability, resource management
• Land resources of the South Burnett region (Vandersee and Kent 1983; 1:250,000) • Land resources of North Burnett region (Donnalan and Searle undated) • Land Resources of the Central Burnett Region (Kent, in prep.)	• 1:100,000 - small area • 1:250,000 - whole catchment	• Atlas of Australian Soils • Soils and irrigation potential of the Ceratodus area,eidsvold, Qld. (D.J.Kent, P. Sorby and R.E.Reid, 1989) • Soils of the Central Burnett area, Qld (De Mooy *et al.* 1977, 1:100,000) • Auburn River Irrigation Suitability Study (Wilson and Sorby, 1991) • Soils of the Riparian Lands of the Burnett River between Mundubbera and Gayndah, Queensland: Suitability for Irrigated Agriculture. (Tucker and Sorby, 1996) • Land Units of the Creek Alluvium and South Eastern area of the Three Moon Creek catchment. (Donnolan and Searle, undated. 1:75000)	• Vegetation survey of Brigalow South (Wilson, B. undated; 1:250,000) • Vegetation survey of SE Qld (Sparshott *et al.* undated; 1:100,000) • 1991 Landcover and vegetation density maps with property boundaries, roads and place names (Qld Statewide landcover and trees study; 1:100,000 and 1:250,000) • Various 1:100000 sheets of Herberium Vegetation mapping, 1997, DOE.	• Understanding and Managing Soils in the Inland Burnett District. (Maher, J. M. Ed., 1993) • South Burnett agricultural lands (Sorby, undated) • Pasture lands of northern Australia (Tothill and Gillies, 1992)

Available Water Resource Information
There are 90 gauging stations within the Burnett Catchment, 57 of which are still operational. Eighteen sites record pluvio-graph data while 7 sites record water quality data. Twelve weirs have been constructed within the catchment as well as 4 dams. The dam sites are located on the upper reaches of the catchment on the Boyne River, on Barker Creek, on Three Moon Creek and on the Nogo River.

This well established gauging network has been used for planning new infrastructure development. A number of dam sites have been identified as part of this process. Currently a WAMP (Water Allociation Management Plan) has been carried out for Burnett catchment and flows are being modelled. Planning for new dam infrastructure is currently underway within the catchment.

Past and ongoing research
An extensive array of past research has been established in the catchment, associated with the major research centres of Narayan (CSIRO) and Brian Pastures (QDPI). The catchment has also been used by other centres, particularly Brisbane, with field sites throughout the catchment. Current research in the catchment is strongly focussed on cropped areas, in particular the Bundaberg sugar cane district, with some of the main issues revolving around groundwater use and contamination, and irrigation efficiency. With respect to grazing management, only one major project was identified in this study, which addresses pasture restoration in wiregrass infected pasture communities (for details refer to research proforma No. 20, Appendix 8.4) and that has a high degree of producer involvement.

Existing Infrastructure

Research infrastructure
A number of research centres occur within the catchment, as well as departmental offices. The Bjelke Petersen Research Station based in Kingaroy services the South Burnett, while the MLA-funded Brian Pastures Research Station at Gayndah services the grazing industries throughout the catchment. Until recently the CSIRO have had a major presence within the catchment at Narayan but this facility is now closing. QDPI offices are located throughout the catchment from Monto through Mundubbera, Gayndah, Murgon to Kingaroy and Bundaberg. Bundaberg, on the coast at the mouth of Burnett River, is a regional centre and has a QDPI and QDNR research facility. The catchment is currently not well endowed with research staff dealing with the grazing industry. There is some competency in pasture management research, hydrology and soils research.

Extension infrastructure
Associated with the District Offices of QDPI/QDNR, there are 29 extension staff. These staff cover a mix of disciplines from animal husbandry, soil conservation, farm water advisory to farm forestry and financial counselling from the various centres. They usually work as a team throughout the catchment to provide an overall service.

Accessibility
The catchment is well serviced by road, rail and aeroplane. The sealed roads network is extensive throughout the catchment and access is possible in all except the most extreme flooding events. Localised access can sometimes be a concern in wet weather as some side roads are unsealed. A rail network exists within the catchment but is of minor importance. Access by air is limited to light aircraft except for Bundaberg which is on the main coastal corridor. Numerous light aircraft facilities are available throughout the catchment if access is denied by wet weather. Telecommunications is available throughout the catchment and remote sites are currently programmed to download data on request.

6.4.3 Fitzroy (QLD)

Biophysical assessment

Spatial variation of erosion susceptibility and actual occurrence
Very broadly, the Capricornia region consists of extensive central lowlands basins surrounded by upland rims of resistant rock. The major portion of the Fitzroy, Belyando and Suttor rivers are contained within the region. Separating the narrow coastal plains from the internal lowlands is the eastern highland zone. This forms a near continuous belt of uplands from 15 to 150 kilometres wide and developed on resistant rocks. Elevations generally average 300-400m but reach to a 1000m in the Clark range west of Mackay and to more than 900m in the Calliope range west of Gladstone. The central plain and lowland zone occupies the major portion of the Capricornia region and includes a number of broad terrain types, including plains developed on Tertiary clays, plains and lowlands on shales, plains and lowlands on basalt, plains on weathered coarse textured sediments, lowlands on varied rocks and alluvium. Bounding these central plains and lowlands to the west and south west are a series of ranges extending in an irregular arch from the Redcliffe Tableland in the north to the Drummond Range in the south west. The southern boundary is comprised of a broad, irregular belt of mountains and hills comprised for the most part of coarse sandstone.

Results of the assessment of intrinsic vulnerability and catchment statistics are presented in Fig. 6.13. Variation of erosion indices is pronounced, with areas indicating potential hotspots of erosion predominantly concentrated along the western, eastern and southern rims of the Capricornia region. These hotspots alternate with areas of lower vulnerability in the Central Plains, in particular when associated with the basalt landscapes. Specific runoff (42 mm) is lowest when compared to the other potential focus catchments, and seasonality of rainfall also tends to be lower than the more northerly catchments in NA. Whilst the range of inter-annual variability of rainfall is as low (Burnett) or lower than the other catchments (expressed as CV of annual rainfall of longterm raingauge records located in the Fitzroy basin, Fig. 6.13), intra-annual variability is high, due to the catchment's location at the interface between the tropical and southern Australian climate regimes.

Gillies (1978) assessed the agricultural land use suitability for the Capricornia region. Using an 8 class land capability classification he found that some 57% of the region was in classes four (4) or better. These land classes would largely occur in the extensive central lowland basin and have the potential for more intensive development either for cropping or improved pasture. However as Nix (1980) pointed out, soil erosion is the major hazard in Capricornia, unless management systems are devised for this area. Some 35% of the region is in classes 6 to 8 and largely occurs in the upland rims surrounding the central basin. It is in these areas that extensive gullying can occur. An example of this is in the upper Nogoa catchment where Ciesiolka (1987) reported widespread and severe gullying, in particular on extremely vulnerable duplex soils derived from various sedimentary rocks. When areas of the central lowland basin are disturbed for cultivation extensive gullying patterns can also develop.

Approximately 30% of the timber in the catchment has been cleared (virtually all brigalow / softwood scrubs) and Tothill and Gillies (1992) indicate that much of the vegetation in the catchment has undergone change in composition towards a deteriorating state (condition B). Within the cleared brigalow scrub sown to buffel grass, risks to erosion are lower.

Impacts of off-site importance
Riparian vegetation along the streams is in a poor state and has been exacerbated by the recent drought conditions. Approximately ten wetlands of national importance have been recognised within the Fitzroy catchment (Blackley *et al.*, 1996), some of which are being

Develop and Implement a Fitzroy Catchment Management Strategy	Fitzroy Catchment Coordinating Group Inc.	Continuing development of a catchment management strategy for the Fitzroy Basin and associated coastal catchments	$323,120
Development and Implementation of a Dawson River Catchment NRM Strategy	Dawson Valley Development Association Inc.	Complete development and implementation of a Dawson River Catchment Natural Resource Management Strategy	$118,238
Evaluating Sustainability of Production Systems in Taroom Shire	Taroom Shire Landcare Group Inc.	Develop a series of vegetation management case studies focusing on: strip bladeploughing of Brigalow regrowth; soil stabilization and erosion prevention; parthenium best practices; repair of degraded areas	$196,463
Property Management Planning Campaign - Central Region Component	Queensland Department of Primary Industries	To fund the activities of a pasture extension officer at Emerald and tow new PMP district officers at Biloela and Emerald	$1,192,587
Project co-ordinator for Taroom Landcare/Resource Information Centre	Taroom Shire Landcare Group	Employ a resource centre co-ordinator	$142,881
Sustainable land use practices in the Theodore District	Theodore Landcare Group	Employment of a part-time co-ordinator	$97,675
Upper Belyando/Suttor River Landcare Project	Belyando Shire Council	To employ a part-time co-ordinator to bring together existing and potential landcare and ICM groups to develop a degradation strategy for the Belyando Shire	$129,058
Vegetation Management within Mimosa Creek Catchment, Fitzroy Basin	Mimosa Catchment Landcare Group	Develop an integrated management plan for rejuvenation and maintenance of vegetation along the alluvial sandstone country within Mimosa Creek Catchment	$62,483
Water Quality in the Fitzroy Catchment - Community Ownership	Queensland Department of Natural Resources	To fill the knowledge gaps and management of causes and processes occurring in ephemeral streams between the farm boundary and major streams	$289,144
Weed awareness in Belyando, Peak Downs and Emerald Shires	Lake Maraboon Landcare Group Inc.	To develop a weed identification card pack of 25 priority weeds in the project area	$37,861
National Wetlands Program			
Brigalow Belt North - Biodiversity Strategy	Queensland Department of Environment	To finalise mapping and assessment of terrestrial and wetland regional ecosystems, and their faunal assemblages	$362,090
Waterwatch			
Co-ordination of the Waterwatch Program across the Fitzroy Basin	Fitzroy Catchment Co-ordinating Group Inc.	To employ a regional co-ordinator to facilitate establishing the waterwatch programme throughout the Fitzroy Basin; to encourage participation; to provide training, information and resources	$129,760

Information provided by NHT, current May 1998

Potential channels of communication

In view of the numerous groups listed above and the present activities of the FBA, there are very good prospects of successfully channeling research outcomes to producers. Several

NAP3 projects are also located in the Fitzroy, and two of them have an erosion/runoff monitoring component at plot scale (refer to research proformas No. 13, 14) that would link well into the proposed research and could provide an additional channel of communication. Moreover, there is scope to draw upon the Central Highlands Regional Resource Use Planning project (refer to research proforma No. 34, Appendix 8.4) to channel outcomes for parts of the Central Highlands and Desert Uplands.

Socio-economic background
Property size varies from 1 800 ha in the Fitzroy shire (outskirts of Rockhampton) to 9 340 ha for Bauhinia (mainly grazing properties in the upper reaches of the Dawson river sub-catchment). The herd size distribution in the region varies widely between the districts. Coastal districts have smaller average property size with 70-80% of them having less than 100 breeders while more than 20% of the central highlands has 300 head or more and 35% of the herds in the Dawson - Callide have 300 head or more. The majority of the herds are cross breed Brahman - British with a slightly less percent of *Bos indicus*. Native pastures provide the bulk of the feed for beef cattle in the region. Approximately 86% of the region is comprised of native pastures, 11% sown pastures and the remaining 6% is cropped. Over 80% of the catchment is freehold or freeholding tenure.

Resource and research information

Available land resource information
Availability of land resource information can be considered high for NA standards. An overview is given in Tab. 6.12. Land evaluation studies are also in progress along the Upper Dawson, Comet, Nogoa and Mackenzie Rivers as part of the investigations for the proposed

Table 6.12: Overview of existing land resource information in the Fitzroy catchment

Land systems	Geology	Soils	Vegetation and land cover	Land capability, resource management
• Lands of the Dawson - Fitzroy Area, Qld (CSIRO 1968, 1:500,000) • Lands of the Isaac - Comet Area, Qld (CSIRO 1967, 1:500,000) • Lands of the Nogoa - Belyando Area, Qld (CSIRO 1967, 1:500,000) • Capricornia coast (Forster in progress; 1:250,000) • Land units of the Fitzroy Region, Queensland. (Gunn and Nix 1977, 1:1,000,000)	• 1:100,000 - small area • 1:250,000 - whole catchment	• Atlas of Australian Soils • Soil association map, Dawson valley region (Isbell 1956) • Fitzroy region resource series, soils (Isbell 1967, 1:1,000,000) • Soil fertility of Central and NE Qld (Ahern *et al.* 1994: 1:1,000,000) • Soils and agricultural use in the Kilcummin area, Qld (Shields *et al.* 1993; 1:100,000) • Soil surveys of the 1:100,000 map sheets of Windeyer's Hill and Banana are in progress • Erosion survey of the Upper Nogoa Catchment. (Skinner *et al.* 1972)	• Riparian study of the Dawson River • Report of riparian and remnant vegetation in Central Queensland • Vegetation survey of Brigalow South (Wilson, B. undated; 1:250,000) • Vegetation survey South Central Qld (Neldner 1984; 1:250,000) • Landcover and vegetation density maps with property boundaries, roads and place names (Qld Statewide landcover and trees study; 1:100,000 and 1:250,000)	• Agricultural land resources and management, Mackay region (Dawson and Turner 1980) • Central Highlands Field manual (Thwaites, undated) • Evaluation of agricultural land in Taroom Shire (Forster 1985) • Evaluation of the Port Curtis - Wide Bay region (Macnish, undated) • Land management manual, Dawson - Callide districts (Turner and Shields 1991) • Land suitability of the Collinsville - Nebo Moranbah regions (Shields 1984) • Pasture lands of northern Australia (Tothill and Gillies, 1992)

Nathan and Comet Dams and soil surveys are being undertaken of the 1:100,000 map sheets of Windeyer's Hill and Banana.

In addition an number of minor soil surveys (Isbell 1954; Shields and Williams, 1991) and assessments of riparian zones have also been undertaken, with emphasis on the Dawson River.

Available water resource information
There are 141 gauging sites in the Fitzroy Catchment, of which 77 are still operational. Pluvio-graph data is available from 22 sites while water quality data is available from 14 (QDNR, 1997). There are 13 weirs within the catchment and 4 dams. The dam sites are located in the upper catchment areas on Kroombit Creek, Callide Creek, Theresa Creek and on the Nogoa River (Fairbairn Dam).

Past and ongoing research
Historically research in the Fitzroy Catchment has been centered on the three research centers of Emerald, Biloela and Rockhampton. The Emerald Research Station established in 1983 is the latest DPI Research Station to be established in the region. Both the Emerald and Biloela research centers have tendered to concentrate on irrigated and dryland cropping research, although grazing research has also been supported. The research centers have also supported off station activities including a number of grazing related research trials. In more recent years the emphasis at both research centers has broadened from just production oriented research to sustainable land management research. Annual Research Station reports detail the range of activities being carried out in the various centers.

With the establishment of the Tropical Beef Centre in Rockhampton, bringing together researchers from QDPI and CSIRO, pastoral grazing management research has achieved a more focussed outlook. Research conducted by QDPI and more recently by the Tropical Beef Center has contributed enormously to our understanding of animal improvement, grazing management and pasture improvement. A specific review of the multitude of reports and publications is beyond the scope of this section.

With respect to grazing impacts and catchment response, a key study was the Nogoa catchment study (Ciesiolka, 1987), triggered by concerns over sediment inputs into the Fairbairn Dam (Skinner *et al.*, 1972). Subsequently, the data collected in the Nogoa study has been utilised to test the applicability of a distributed parameter hydrology model (ANSWERS) to model grazing impacts on runoff generation (Connolly *et al.*, 1997a; Connolly *et al.*, 1997b). However, catchment size was limited to 10 ha.

Presently, a number of research projects relevant to the scope of this study are being carried out in carious locations of the catchment. The majority are focussed on issues related to plot to paddock scale studies of pasture stability and its management (refer to research proformas No. 3, 14, 15; Appendix 8.4), problems of woody weed control (proforma No. 26) and producer designed monitoring programs (proforma No. 22). A number of projects were also identified specifically addressing water quality issues (proforma No. 28) and algal bloom problems (proforma 29). Marine impacts are being partly assessed by AIMS (proforma No. 32).

Existing infrastructure

Research infrastructure
The Fitzroy catchment is well serviced by research infrastructure, mainly out of the Tropical Beef Center (a joint venture of CSIRO, QDPI and CQU) located in Rockhampton. In addition

several centers are located inland within the catchment. An overview of institutions, staff and locations relevant to research on grazing management is given below:

1. Department of Primary Industries
   - Research in grazing land management (12 staff based in Rockhampton and Emerald)
2. Department of Natural Resources
   - Research in land, water and riverine management (8 staff based in Rockhampton, Emerald and Biloela).
3. Department of Environment
   - Research in biodiversity management (6 staff based in Rockhampton and Emerald).
4. Central Queensland University's "Institute for Sustainable Regional Development" (Rockhampton).
   - Centre for Land and Water Resource Management (National Eutrophication Management Plan)(12 staff).
   - Rural Social and Economic Research center (12 staff).
   - Primary Industries Research Center Plant Sciences Group (15 staff).
   - Primary Industries Research Center Animal Sciences and Production Group (20 staff).

Extension infrastructure

Major state agency extension infrastructure with staff numbers is listed below:

1. Department of Primary Industries
   - Extension in grazing land management (6 staff based in Rockhampton and Emerald).
   - Future*profit* (4 staff based in Rockhampton and Emerald).
2. Department of Natural Resources
   - Extension in land, water and riverine management extension (10 staff based in Rockhampton, Emerald and Biloela).
3. Department of Environment
   - Extension in biodiversity management (4 staff based in Rockhampton and Emerald).

Accessibility

Level of remoteness in the Fitzroy catchment is low as all parts of catchment are within two hours travelling time of the major centers Rockhampton, Emerald or Biloela, serviced by an extensive net of all weather highways (Capricorn, Dawson, Gregory, Leichardt highways). Wet season access to almost all parts of the catchment is given except in major floods, when access may be restricted by flooding. Several regional centers have regular air service (Rockhampton, Emerald, Clermont), and given the higher density of main highways and the higher population density, extensive areas are within mobile phone range.

6.4.4 Ord

Biophysical assessment

Assessment of the spatial variation of erosion susceptibility

As can be gathered from Fig. 6.14, a high potential for sheet/rill erosion is widespread throughout the catchment and indices of susceptibility to gully and channel erosion indicate some severe hotspots, placing the Ord as the top ranked catchment with respect to overall intrinsic vulnerability. This is corroborated by the Ord having the highest specific discharge (runoff, 93 mm) of all short-listed catchments. On the other hand, these results require some qualification. Whilst the magnitude and distribution of erosion indices derived from the GIS analysis conducted in this study matches fairly well to known occurrences of erosion in the QLD catchments, there are a few noticeable discrepancies in the case of the Ord. On the one hand, some portions of the Ord with known high incidence of gully erosion (Hardman Basin,

De Salis, 1993; Novelly, 1994)) coincide with areas of low susceptibility (central southern part, Fig. 6.14b), and on the other hand, extensive areas presenting high indices of sheet erosion lie within the ranges, that are often characterised by large areas of outcrop that essentially have been completely denuded and cannot any longer act as sources for sediments.

Two causes for these discrepancies are possible. In one case, areas of high intrinsic vulnerability may not have been affected by grazing owing to their extreme low productivity, and hence there is no indication of ongoing erosion hazards, in contrast to areas of lower vulnerability that have been subject to extreme grazing pressures and therefore have degraded significantly. The other possibility lies in misclassification of soil erodibility, with K factors being assigned to areas that have been denuded, or the relative weighting of the factors in equations [2] and [3] not adequately reflecting the erosional processes typical of the highly seasonal rainfall regime in north-western Australia and the Top End, compounded by frequent pre-wet season burning. Possibly, therefore, the assessment of intrinsic vulnerability may have been overestimated in some instances. On the other hand, the very low cattle density may also be the reason for current low levels of actual erosion.

Apart from specific areas such as the Ord River Regeneration Reserve, active erosion is not a widespread problem in the Ord River catchment and is very point specific. The survey of the Ord River catchment (Wasson *et al.*, 1994) suggests that the degree of erosion and its severity appears to depend upon:

- topographic position within the landscape;
- degree and length of slope;
- vegetative cover, with this often related to proximity to stock water;
- inherent stability (or rather instability) of the soil and underlying rock;
- disturbance of the soil surface.

In general, the most erodible soils are the shallow soils, yellow earths and red sandy soils directly over limestone. In particular, the friable calcareous clay loam to light clay soils are extremely dispersible. When exposed by overgrazing to the effects of raindrop splash and extensive overland flows, these soils are prone to rapid and extreme erosion. Consequently, they have the potential to contribute large amounts of silt to the river systems if not protected by vegetation.

Range condition in the Ord River catchment is characterised by its variability. Data from the individual ground-based traverses and individual surveys indicate that condition changes from "good" to "poor" in the space of a few kilometres or across a fence. Land systems are variable in range condition, with, for example, 84% of the Elder land system in "poor" condition, while the Argyle and Lubbock land systems recorded no "poor" condition traverse points.

Of the 30 land systems surveyed on the Western Australian portion of the Ord River catchment from 1990 to 1993, 13 were assessed as having over 50% of the surveyed area in "good" range condition. With a combined area within the Catchment of approximately 13850 km^2, this represents approximately 30% of the catchment's total area. In contrast, four land systems were assessed as having 50% or more of their area in "poor" range condition. This represents around 12% of the catchment's area or approximately 5400 km^2. However, in the case of the land systems with 50% or more of the surveyed area in "poor" range condition, two systems, Ivanhoe and Dinnabung, were assessed at only 6 and 3 points respectively. Of the "poor" condition land systems, two predominate. These are the Nelson and the Elder land systems. Of these, 1661 km^2 of the Nelson (total 3510 km^2) and 1192 km^2 of the Elder (total 1390 km^2) land systems occur within the boundaries of the Ord River Regeneration Reserve

within Western Australia. Even assuming that the survey results from the Dinnabung and Ivanhoe land systems are representative of the land systems as a whole (despite the limited number of survey points), then of the approximately 5400 km^2 of land systems with 50% or more of the area in "poor" condition, over 2800 km^2 (53%) of this area occurs within the boundaries of the Ord River Regeneration Reserve.

Range condition is very much related to the pastoral potential and resilience of the various land systems and pasture types. In general, the soft spinifex/ribbon grass pasture type (*Triodia pungens/Chrysopogon fallax*) and the blacksoil plains (*Astrebla spp.*) are probably the pasture types most preferred by cattle. The former type is common throughout the Ord River catchment, particularly in areas with better moisture relationships such as swales, small drainage floors, pans and depressions. This type is particularly well developed on the elevated stable plains of the O'Donnell land system and on the flatter areas of the Richenda land system where it merges with the more lobed spinifex type (*Triodia intermedia*). The blacksoil plains areas are common inclusions within land systems, except for the Inverway, Wave Hill and Argyle land systems where they dominate.

Fire is of major importance. Large areas of the Ord catchment grasslands burn annually, with early wet season convective thunderstorms falling on bare soil over large areas. Clearing of native vegetation within the catchment (apart from irrigated areas downstream of Lake Argyle) is virtually non-existent.

Important off-site impacts
Within the Ord catchment there are two major dams (the Ord River dam at Lake Argyle and, approximately 50 km further downstream, the Diversion Dam at Lake Kununurra). There is also a weir at the Dunham River Reservoir on the Dunham River approximately 75 km from the confluence of the Ord and Dunham Rivers. Off-site impacts at a catchment scale are mediated by the presence of the Ord River dam at Lake Argyle. Apart from sediment removal in water released for irrigation, Lake Argyle traps all other silt coming from the grazed catchment within approximately 100 km upstream from the mouth. Consequently, impacts upon marine systems and on coastal fisheries may presently be of lesser importance than in the other short-listed catchments.

Representativeness of catchment to northern Australian landscapes
The biogeographic regions of the Victoria-Bonapart and the Ord-Victoria Plains are largely represented in the Ord River catchment (Thackway and Cresswell, 1995). These biogeographic regions contain a diversity of landscapes ranging from rugged sandstone terrain and dissected volcanic country to gently undulating inland and coastal plains. These landscapes occur in other northern Australian biogeographic regions such as the Northern Kimberley, Top End Coastal. Central Arnhem, Gulf Coastal and Gulf Plains.

Producer and community issues

Relevance of catchment to the beef industry
The Ord River Catchment is one of the two major pastoral catchments in the Kimberley region (Kimberley area is 320,000 km^2). The Ord River catchment in the eastern Kimberley Region of Western Australia and the north-west of the Northern Territory is drained by the 650 kilometre long Ord River that flows into Cambridge Gulf near Wyndham. The catchment covers an area of approximately 46 700 km^2 in Western Australia and extends into the Northern Territory to the Victoria River, with a total area of 55,500 km^2. The other major catchment in the Kimberley is the Fitzroy River catchment.

Average cattle numbers (72,425) are low, partly due to large areas of fairly unproductive land and partly because of major exclusion zones such as the Bungle Bungle NP and the Ord Regeneration Reserve. Mean carrying capacity is also low (0.0208 cattle/ha) and quite variable, ranging from 0.10 to 0.12 per ha for blacksoil plain (*Astrebla spp*) to less than 0.02 per ha for hilly terrain and spinifex areas. Operations are generally extensive, although infrastructure development (more fences, denser artificial waterpoint network) and cattle control has been improved by Brucellosis and and Tuberculosis Eradication Campaign (BTEC). However, paddocks are still large (each 5,000 to 20,000 ha) and spatially variable (slope/soil type/pasture type) suggesting considerable variation in rangeland resilience and condition.

Producer awareness of erosion problems and off-site problems
Because of the large size of pastoral leases (see below) and multiple-lease ownership, "off-site" is a difficult concept for some managers/owners. Issues associated with the Ord River Irrigation Area, the Ord River Regeneration Reserve and sediment movement into Lake Argyle have been on-going for 25 years. This includes communication of Ord River catchment study (Novelly, 1994) project looking at sediment yield of the early 1990's. So, the "off-site" issue is there, but very much as a background issue.

However, there are on-going programs of pastoral lease survey and rangeland monitoring (a combination of soil condition and pasture condition) that provides regular updates of rangeland condition (see Tab. 2.3) which, in turn, keeps "on-site" condition in the forefront. This has direct spin-offs for "off-site" condition.

Assessment of producer awareness and community involvement
There are a series of Land Conservation Districts covering the Kimberley, each with a LCD Committee. The relevant one in the Ord River catchment is the Halls Creek-East Kimberley LCD. This has been functioning since 1989, and is an excellent communication channel to access land managers. There used to be far more community involvement, shire councils, other government agencies (Department of Conservation and Land Management/Bushfires Board) and mining companies, but this is now sporadic. Generally, pastoralists attend with Agriculture WA "support" (via a nominee of the Western Australia Commissioner for Soil Conservation).

Table 6.13: Overview of current and planned NHT funded projects within the Ord catchment

Project	Lead organization	Objective	Total project cost
National Landcare Program			
Ord Irrigation Area Watertable and Water Quality Monitoring	Agriculture Western Australia	To co-ordinate activities and the supply of information between farmers, industry, the community and government agencies; to facilitate and increase monitoring activities; and to provide support for educational training activities	$33,354

Information provided by NHT, current May 1998. Database incomplete for WA.

This group is moving away from an emphasis on "landcare" and conservation to more general issues of property management. However, they are still an excellent focus for landcare issues and the group has received funding from both WA Landcare and NLP (now NHT) for on-ground projects. Considering the size of leases, the "unit of thought" is the property rather than the catchment, although property size generally implies several large sub-catchments.

Potential channels of communication
Channels of communication are good. The LCD is an excellent focus and it is linked in with other regional LCD's. The Kimberley Beef Industry Development Team (KBIDT) is another excellent source of communication, as well as acting as a focus group. There is also a good network of communication through the regional Pastoral and Agricultural Memos.

Socio-economic background
Property size ranges from 100,000 ha to 400,000 ha, often with several leases run by the one owner/manager. Large companies (Consolidated Pastoral/Kidman/Heytesbury Pastoral/E G Green & Sons) own multiple leases with over 1 million ha and over 45,000 cattle. Minimum commercial herd size is about 4,000 to 5,000 head.

Tenure is either pastoral leasehold, "special grazing lease" or aboriginal freehold. There are no "freehold" pastoral lands. Because of the tenure ("public land") and the reporting process to the Western Australia Pastoral Lands Board, range condition information is good.

Debt levels are variable. There have been good seasons since 1992 and a buoyant live cattle market (at least until late 1997) so incomes have been good. Large pastoral companies are presumably well structured, while aboriginal-owned pastoral leases have external funds (ATSIC (declining) and the Indigenous Land Corporation). Off-property income levels would be variable and tourism on leases is expanding in a few cases..

Available land and water resource information
Resource information is mixed, ranging from land systems surveys for most of the catchment to several minor detailed surveys associated with the development of irrigation (Burvill 1945; Aldrick *et al.* 1990). An overview is given in Tab. 6.14.

Table 6.14: Overview of existing land resource information in the Ord catchment

Land systems	Geology	Soils and erosion	Vegetation and land cover	Land capability, resource management
• Lands of the Ord - Victoria Area, WA and NT (Stewrat *et al.* 1970; 1:1,000,000) • Lands of the lower Ord and Keep valleys, NT and WA (Stewart 1969; 1:250,000) • Land systems of the Ord River catchment, NT (Aldrick *et al.* 1978; 1:100,000)	• 1:250,000 - whole catchment	• Atlas of Australian Soils • Investigation map of the lower Ord (Stone and Beer 1981: 1:100,000) • Soil and salinity survey of the Ord and Keep Rivers. (1:250 000; Stoneman 1963) • Ord River Upper Basin Erosion. (Teakle 1944)	• Investigation map of the lower Ord (Stone and Beer 1981: 1:100,000) • NT vegetation map (1:1,000,000)	• Pasture lands of northern Australia (Tothill and Gillies, 1992)

The WA Water & Rivers Commission has an office in Kununurra, with staff associated with gauging all Kimberley rivers. There are approximately 12 major gauging stations in the Ord Catchment, with a variable length of record. Other minor gauging stations for which limited data also exist.

Past and ongoing research
A focus of past grazing related research has been on grazing management and land condition relationships. With respect to grazing impacts on catchment response, the Ord River is the only NA catchment in which an attempt at sourcing sediments and relating them to grazing management has been undertaken (Novelly, 1994: Wasson *et al.*, 1994). As already pointed out elsewhere, this study quite unequivocally has shown that thresholds exist to trigger gully erosion that once exceeded by excessive grazing pressure lead to gully formation. Head-cutting will then proceed until a new landscape equilibrium has been reached, irrespective of conservation measures taken. The study offers some valuable methodological approaches and the sediment delivery data could serve as an important benchmark for follow-up studies to improve our understanding of long-term trends.

Existing infrastructure

Research and extension infrastructure
Agriculture WA has the Frank Wise Institute in Kununurra. There are 3 rangeland professionals and a beef cattle husbandry/management officer among other staff (some associated with irrigated farming research), including technical staff. The infrastructure on the Ord River Regeneration Reserve (including visitor accommodation) associated with previous research activities has recently been removed. Extension infrastructure is good, with staff based in both Kununurra and Halls Creek. Links to the Halls Creek-East Kimberley LCD are also very good.

Accessibility
The Ord River Catchment is bisected by one major highway (the Great Northern Highway) that can be cut in several places during the wet season. All other access is via unsealed road or via station tracks/roads. Road closures are common on unsealed roads in some wet seasons. Dry season access (April to November) is good throughout the catchment.

6.4.5 Victoria River

Biophysical assessment

Assessment of spatial variation of erosion susceptibility
An overview of the distribution and magnitude of erosion indices for the Victoria River catchment is provided in Fig. 6.15, together with summary statistics on key biophysical characteristics. Intrinsic vulnerability to sheet/erosion appears high, and the assessment of susceptibility to gully/channel indicates the presence of some major hotspots. However, the same caution to the reliability of the assessment applies as already discussed for the case of the Ord River.

In the 1970's and 1980's, detailed surveys were undertaken in the Victoria River District (VRD) to assess erosion and to develop relationships between erosion, soils and landform (Aldrick *et al.*, 1978, Wood *et al.*, 1979, Condon, 1986). These surveys were conducted at scales of 1:100,000 and 1:250,000. The Condon survey remains the most comprehensive regional erosion study, surveying an area about one-third the size of the entire VRD or 48,000km^2.

Condon identified eleven forms of erosion mapped at 1:100,000 scale ranging from limited to severe. Approximately 2.4% or 1160 km² of the study area was suffering from moderate or severe erosion, or land degradation that would lead to erosion assuming no change in land management practices. Much of this erosion was along the Victoria River, near the Victoria River Downs Station, which was the original homestead in the District established in 1883.

The cause of severe erosion, particularly fan and finger gullying, was due to the proximity of highly erodible, soft duplex and calcareous soils to longer lasting permanent waterholes in the rivers and principal creeks. These watering points were extensively used by large numbers of cattle in the earlier days (pre-1970's) of open range management when stock were not controlled. Generally fan and finger erosion was localised, confined to major riparian areas, whereas extensive moderate to severe sheet and gully erosion commonly occurred on gently undulating country at the foot of steep slopes.

The upper Ord River catchment in the western VRD (an area of approximately 11,000 km²) has also experienced serious erosion. The survey by Aldrick *et al.*, at 1:100,000 scale, identified three land systems susceptible to erosion. In particular, red earth and calcareous soils (which support preferred pasture) occurring on colluvial slopes and in drainage lines were among the most susceptible areas at risk to erosion.

Since the advent and completion of the National Brucellosis and Tuberculosis Eradication Campaign (BTEC) in the 1980's and early 1990's, the pastoral industry in the VRD has become more management intensive (eg. fencing, use of artificial waters and improved animal husbandry). This significant change in land management has, in many instances, led to natural revegetation of eroded areas through the general reduction in stock numbers, particularly wild cattle including feral donkeys and horses.

Feral animal control is an important issue to pastoralists in the VRD even though past eradication programs have been quite successful. A survey conducted in 1988 estimated numbers of feral donkeys at 65,000 with an additional 27,000 feral horses (CCNT, 1988). In 1992 estimates of feral donkeys were at 37,000 and feral horses at 24,000 (Saalfeld, 1992).

Important off-site impacts
There are currently prawn and shark fisheries with smaller scale Barramundi fisheries operating in the Joseph Bonapart Gulf. The area also has potential for commercial mud crabs harvesting. Massive tidal flows and shallow waters occurring in the Gulf however are logistical concerns for large scale operations. There is presently no significant aquaculture in the Gulf primarily due to the lack of infrastructure in the region. Substantial outflows of freshwater and sediment loads from rivers in the wet season contribute to fluctuating water quality, thus having negative implications to aquaculture operations in the Gulf. In the Ord River system and in particular Lake Argyle there are small scale Barramundi and Trochus farming with potential for expansion. Agricultural ventures using water from Lake Argyle for irrigation that require the use of pesticides may conflict with aquaculture operations if water quality in the lake is affected.

Representativeness of Victoria River catchment to Northern Australian landscapes
Similar to the case of the Ord River, the biogeographic regions of the Victoria-Bonapart and the Ord-Victoria Plains are represented in the Victoria River District (Thackway and Cresswell, 1995). These biographic regions contain a diversity of landscapes ranging from rugged sandstone terrain and dissected volcanic country to gently undulating inland and coastal plains. These landscapes occur in other northern Australian biogeographic regions such as the Northern Kimberley, Top End Coastal. Central Arnhem, Gulf Coastal and Gulf

Plains. Vegetation types in the VRD have been described as similar to vegetation occurring at the same latitudes across northern Australia (Perry, 1970).

Producer/community issues

Relevance of the Victoria River catchment to the beef industry
The Victoria River catchment carries approximately 195,000 head of cattle, with stocking densities averaging 0.031 animals/ha (based on actual grazed area of about 60,000 km^2). Ranking within the North Australian beef industry places the catchment at 17th position. However, from a regional perspective, the Victoria River is the most important beef producing catchment in north-western Australia, in particular since the advent of the live cattle export industry via Darwin.

Producer awareness and community/producer involvement
Until into the early 1980's stations and communities within the Victoria River catchment were remote and people were self reliant and insular. The pastoral industry was traditional in its thinking. With the implementation of the BTEC, the pastoral industry became more focussed, enforcing a higher cost structure and level of development (Stockwell and Andison, 1996). The requirements of the BTEC led to a greater intensity of group actions, so that following the BTEC, with concurrent improvement in communications and infrastructure, a number of active landcare groups and best practice groups have formed. This has brought about a greater demand for provision of field days, demonstration sites and courses. Currently, the major grazing management issues in the catchment are thought to include Native Title, stock management and productivity, live export markets, fire management, feral animals and land condition.

Potential channels of communication
The largest single producer driven entity is now the Victoria River District Conservation Association (VRDCA), which goes beyond the catchment boundaries and has approximately forty active members. The VRDCA is engaged in long term planning to ensure the sustainability of the pastoral industry through holding group meetings and fostering the exchange of ideas. Since most its membership is comprised of producers, the potential is high for research outcomes being taken up in the catchment. The CRC-SDTS, Local Best Practice Groups and Rural Bushfires Council, a number of NHT funded projects that have also been initiated or are being planned (Tab. 6.15) and the ongoing NAP3 funded project on sustainable beef production systems for the semi-arid tropics of the NT (Rodd Dyer, NT-DPIF; for details refer to proforma No. 12, Appendix 8.4) are other potential channels of communication.

Socio-economic background
In terms of tenure and property sizes, there are some marked differences when compared to Queensland. The majority of the catchment is under leasehold, with increasing portions of the catchment declared National Park and some aboriginal trust lands. In general, pastoral leases are very large with average sizes ranging from 3000 to 6000 square kilometres. In some cases, leases or properties are corporately owned or managed, with significant investments in staff training (Stockwell and Andison, 1996).

Table 6.15: Overview of current and planned NHT funded projects within the Victoria River catchment

Project	Lead organization	Objective	Total project cost
National Landcare Program			
Development of an Integrated Weeds Strategy in the Victoria River District	Victoria River District Conservation Association	To develop an integrated weeds strategy in the Victoria River District	$41,220
Fencing of Pasture Establishment Trials	Victoria River District Conservation Association	To assist the Victoria River District with the initial costs of purchase and erection of exclusion fencing around native grass establishment trials	$17,690
Identify Viable Local Native Grass Seed Harvesting Methods	Victoria River District Conservation Association	To investigate the different harvester types and determine the most cost efficient for use by pastoralists on native grass species in the semi-arid tropics; to obtain a range of perennial native grass seed for distribution to Landcare groups, government departments and landholders	$50, 230
Project Co-ordination and Support	Victoria River District Conservation Association	To ensure projects are appropriately developed, implemented, co-ordinated and recorded. Also to review the document 'An Integrated Landcare Program for the VRD' as a strategy for total catchment management	$55,000
Sustainable Fire Management for the Sturt Plateau and VRD, NT (Project not yet certain)	Bushfires Council of the NT	Develop guidelines, including economic and ecologic assessments, for implementing fire management in the Sturt Plateau, Ord-Victoria Plains and Victoria Bonaparte biogeographic regions	$469,413
Water Resources of the Western Victoria River District	NT Department of Lands, Planning and Environment	Twenty one properties in the western Victoria River District are being studied. Their water resources, both surface and underground are being mapped, described and evaluated. A compilation map for the whole of the Victoria River District will be prepared during 1997/98 and a summary report prepared	$170,367

Information provided by NHT, current as of May 1998.

Resource and research information

Available land resource information

The whole of the catchment has been surveyed at a land systems level at 1:1,000,000 scale (Stewart *et al.*, 1970) and more recently, work in progress includes surveys at a land unit level at 1:100,000 scale (Tab. 6.16). The latter will be available in digital format and containing information on lithology, landform, soil and vegetation. Through an ongoing CRC-SDTS project (CRC project 3.1; for details refer to research proforma No. 21), land condition is being systematically monitored through a combination of satellite image analysis and ground truthing. The latter would prove to be highly advantageous to assess current levels of erosional activity.

Table 6.16: Overview of existing land resource information in the Victoria catchment

Land systems	Geology	Soils and erosion	Vegetation and land cover	Land capability, resource management
• Lands of the Ord - Victoria Area, WA and NT (CSIRO 1970; 1:1,000,000) • Lands of the lower Ord and Keep valleys, NT and WA (Stewart 1969; 1:250,000)	• 1:250,000 - whole catchment • Land units of the Victoria River District, NT (1:100,000; to be completed 1999)	• Atlas of Australian Soils • Land systems and erosion on part of the Humbert River Station (Wood *et al.*, 1979) • Reconnaissance erosion survey of the VRD (Condon, 1986)	• NT vegetation map (1:1,000,000)	• Pasture lands of northern Australia (Tothill and Gillies, 1992)

Available water resource information

There are currently several ongoing monitoring programs to assess river health linked to the National program - AUSRIVAS. Water quality and macro vertebrate samples are collected in the Keep, Victoria and Ord Rivers from approximately 20 reference sites. Water heights have been monitored along the Victoria River at 60 stations and at 8 stations on the Ord River within the Northern Territory. Not all of these stations are regularly monitored and flow measurements at critical sites have been calculated by manually measuring channel width and calibrating water height data. Water quality and stream height/flow data is assessable in digital format with appropriate approval from relevant organisations. An NHT funded project, Landcare Assessment of Waterways Top End NT, has recently been completed. The focus of this study was assessing the condition of waterways and land corridors within the Victoria River Catchment.

Past and ongoing research

The Victoria River catchment has in the past received considerable attention, both from federal and state agencies. The former CSIRO Division of Tropical Crops and Pastures, which operated a research station in Katherine until 1994, focussed most of its work on improved pastures, plot scale stocking density trials and some grazing ecology work. Since its establishment, the CRC-SDTS has focussed a major part of its research through its programs 1 and 3 on the Victoria District by selecting it as a case study area. The CSIRO Division of Wildlife and Ecology, currently still very active through its group based in Darwin, has focussed its research within the CRC-SDTS on forms and functions of savannas along a transect from Darwin through to the eastern and south eastern part of the Victoria River (for details refer to research proforma No. 11, Appendix 8.4). This more landscape ecology oriented work would provide an important link to some of the hillslope scale nutrient dynamics work envisaged in the conceptual framework outlined in chapter 5. However, with the exception of the ongoing satellite based land condition (proforma No. 21), the majority of research has focussed on issues related to pasture management at plot to paddock scales (proforma No. 12), with practically no catchment scale hydrology work being conducted.

Existing infrastructure

Research and extension infrastructure

The Kidman Springs Research Station and the stocking rate trial at Mt. Sanford Station are the main sites for research located in the Victoria River Catchment. Both sites are operated

by NT-DPIF. All other research and extension infrastructure for the VRD is based in Katherine (NT-DPIF), Darwin (CRC-SDTS) and Palmerston (NT-DPLE). Approximately 50 research and extension staff are involved across the three institutions.

Accessibility
The catchment is serviced by two major sealed highways (Victoria and Buntine Highways). As a result, access to most of the areas within the catchment is restricted to graded dirt roads and property tracks. Accessibility is impaired during the wet season, with the main highways occasionally cut-off at major river crossings, so that overall, the catchment can be considered moderately to poorly accessible.

6.5 Ranking of short-listed catchments and recommendations

In the final step of catchment ranking, the five short-listed catchments were rated against the criteria established and the information collated in the preceding evaluation. Rating was carried out qualitatively using three categories (1 = high; 2 = moderate; 3 = low). The socio-economic criterion was excluded, as it was felt that not sufficient information had been collated at the time of report compilation to warrant use as a rating criterion.

The results of the rating are presented in Tab. 6.12. From the overall assessments of ratings the Burdekin and Fitzroy were perceived as the most suitable catchments, scoring high to moderate ratings for all assessed criteria. These two catchments were followed closely by the Burnett, and then with some distance by the Victoria and Ord catchments. Main limitations for the latter were the lower perceived levels of producer awareness and reduced potential to adopt improved grazing management techniques aimed at reducing soil loss.

Table 6.12: Ranking of short-listed catchments according to relevant assessment criteria

Assessment Criteria	Burdekin	Burnett	Fitzroy (QLD)	Ord	Victoria
Potential/actual erosion	1	1	1	1	1
Severity of off-site impacts	1	1 - 2	1	1 - 2	1 - 2
Representativeness	1	2	1 - 2	1	1
Relevance to beef industry	1	1	1	3	2
Level of producer awareness	1 - 2	1 - 2	1 - 2	2	2
Producer involvement	1 - 2	1 - 2	1	2	2
Communication channels	1 - 2	1 - 2	1 - 2	2 - 3	1 - 2
Available land resource info	1	1 - 2	1	2 - 3	1 - 2
Available water resource info	1 - 2	1 - 2	1 - 2	2 - 3	2
Past and ongoing research	1 - 2	2	1 - 2	1 - 2	2
Research infrastructure	1	1 - 2	1	2 - 3	2 - 3
Extension infrastructure	1	1	1	2	2
Accessibility	1 - 2	1	1 - 2	3	3

On the basis of the above assessment we make the following recommendations:

- to select either the Burdekin or the Fitzroy catchment as the focus catchment for future research of grazing impacts on sediment and nutrient loss

- in order to account for the marked differences in climate and landscape conditions in north western Australia, to select the Victoria catchment as a future case study catchment to apply and test the extrapolation of tools developed in the focus catchment study and to assess their utility for other catchments in NA

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8. Appendices

8.1 Terms of Reference

8.2 Members of core team and reference group

8.3 Workshop reports

8.4 Research proformas

8.5 Result documentation of the assessment of intrinsic vulnerability

8.1 Terms of Reference

1. Prepare a comprehensive inventory and analysis of current projects related to water and nutrient flows and catchment management in northern Australia as they relate to the northern beef industry, and especially to grazing management.

   It is anticipated that the analysis will build in the recent review by Rosemary Hook and will provide for each current project:

   - details of the problems being addressed and the objectives of the project
   - a summary of methods being used
   - location of the research work
   - a brief summary and analysis of findings to date
   - the organisation responsible
   - contacts for further information
   - timeline of the project
   - sources of funding
   - expected outcomes and implications for the grazing industry.

   It is also anticipated that a concise summary, not exceeding two pages, will be provided for each current project.

   Completion of this phase of the project will clearly require collaboration across various agencies and organisations to bring together the datasets required. It is anticipated that the contracted consultant will sub-contract other organisations as required to achieve such information collation. The project might also require the establishment of a short-term inter-agency advisory group.

2. Building on the work already completed by Rosemary Hook and after collation of addition information as indicated in (1) above, identify any starkly apparent gaps in current work relating to catchment management, water quality and nutrient flows as they relate to the northern beef industry and provide a rationale for inclusion of issues identified.

3. Conduct a scoping study in which catchments are assessed against a number of agreed criteria defining priorities for further research which will assist in addressing perceived risks to water quality and nutrient flows arising from the northern beef industry and grazing management within that industry. The intention of this scoping exercise is to identify a catchment in which to conduct NAP3-funded research, as resources are only likely to be available for one such study.

   Criteria should include:

   - importance of the catchment within the northern beef industry
   - potential for the grazing industry to affect land and water quality
   - climate and geomorphology of the region
   - the extent to which grazing impacts might be distinguished from other processes and land uses within the catchment
   - existing interest within the catchment community in information likely to generate by further research in this field
   - the extent to which extension processes are already in place to facilitate rapid integration of research results into catchment planning and specifically to properties within that catchment

- the extent to which results obtained in the selected catchment are applicable to other locations.

4. In conducting this scoping study, the successful consultant(s) should also document and review land system and other resource mapping available in the various catchment across northern Australia and their appropriateness to whole catchment and property management planning.

5. Report to the North Australia Program on the issues addressed in items 1-4.

8.2 Members of core team and reference group

Core team

Christian Roth, CSIRO LW, Townsville - Team leader
John Aldrick, CSIRO LW, Canberra
Andrew Ash, CSIRO TAG, Townsville
Rosemary Hook, Land and Soil Consulting, Canberra
Gary Jones, CSIRO LW, Brisbane
Paul Novelly, Agric. WA, Kununurra
David Orr, QDPI, Rockhampton
Mick Quirk, QDPI, Charters Towers
Mark Sallaway, QDNR, Bundaberg

Reference group (participants in workshops; contributors to report)

Jocelyn Baker, producer
Chris Barnes, CSIRO LW, Canberra
Jenny Bellamy, CSIRO TAG, Brisbane
Leith Boully, producer, Dirranbandi
Col Brett, producer, Charters Towers
Jon Brodie, GBRMPA, Townsville
Robin Bruce, QDNR, Indooroopilly
John Childs, CRC-SDTS, Darwin
Allan Dale, CSIRO TAG, Brisbane
Richard Davis, CSIRO LW, Canberra
Heather Hunter, QDNR, Indooroopilly
Judy Lambert, MLA/NAP3, Sydney
Greg McKeon, QNDR, Indooroopilly
Graham Miller, producer, Rockhampton
Chris Moran, CSIRO LW, Canberra
Jon Olley, CSIRO LW, Canberra
Ian Poiner, CSIRO MAR, Cleveland
Ian Prosser, CSIRO LW, Canberra
Mark Silburn, QDNR, Toowoomba
Kirk Smith, producer, Charters Towers
Wendy Tyrell, BHP, Brisbane
Barry Walker, MLA/NAP3, Brisbane
Joe Walker, CSIRO LW, Canberra
Bob Wasson, ANU, Canberra
John Williams, CSIRO LW, Canberra
Blair Wood, NTDPLE, Palmerston (NT)
Don Yule, QDNR, Rockhampton

8.3 Workshop reports

Summary report on 1st workshop

Workshop objective

The objective of this one day workshop was to bring together the core team of the scoping study with experts in the reference group to identify and discuss criteria and information sources and to develop a conceptual framework that would provide the guidelines for assessing catchments in Northern Australia with respect to catchment management, water quality & nutrient flows as they relate to the northern beef industry. Some discussion was also held on perceived critical research issues relevant to catchment scale research within NAP3.

Date and Venue

The first workshop was held as planned on the 12th December 1997 in the Christians Lab (former Division of Water Resources) on the CSIRO Black Mountain site, Canberra. It was generally a very useful workshop, and the workshop participants felt that it had achieved all of its objectives.

Participants

John Aldrick, CSIRO LW, Canberra
Chris Barnes, CSIRO LW, Canberra
Richard Davis, CSIRO LW, Canberra
Rosemary Hook, Land and Soil Consulting, Canberra
Jon Olley, CSIRO LW, Canberra
Ian Prosser, CSIRO LW, Canberra
Mark Sallaway, QDNR, Bundaberg
Joe Walker, CSIRO LW, Canberra
John Williams, CSIRO LW, Canberra
Andrew Ash, CSIRO TAG, Townsville
Jenny Bellamy, CSIRO TAG, Brisbane
Heather Hunter, QDNR, Indooroopilly
Paul Novelly, Agric. WA, Kununurra
David Orr, QDPI, Rockhampton
Christian Roth, CSIRO LW, Townsville
Rob Vertessy, CSIRO LW/CRCCH, Cbr
Bob Wasson, ANU, Canberra
Don Yule, QDNR, Rockhampton

Outcomes

- the effect of grazing on sediment and nutrient flows as a result of water erosion was considered to be one of the critical issues facing sustainability and off site impacts of beef production in northern Australia. Other degradation processes, such as groundwater contamination, soil structural decline, wind erosion, dryland salinity and dryland acidification were either considered of lesser importance or are already being addressed through NAP3 or through other programs (eg NDSP, NEMP);
- a survey based on a suite of questionnaires to be distributed through the members of the core team was considered the most efficient means of updating the information on ongoing research and extension projects already provided in Rosemary Hook's report.
- given the time and resource limitations, it was agreed that a three-step screening approach using a combination of GIS analysis techniques and expert opinion inputs was the most appropriate procedure to identify suitable focus catchments.
- there was general agreement in the workshop that the final report should go beyond the mere identification of research gaps and potential focus catchments, but should also provide NAP3 with recommendations on possible collaborative inter-agency research frameworks to address the priority research issues.

Summary report on 2nd workshop

Workshop objective

The objective of the second one day workshop was to bring together the core team of the scoping study with experts in the reference group and industry stakeholders to present and discuss the results achieved with respect to the selection of potential focus catchments, the research priorities identified and ideas regarding a conceptual framework to address the research issues. The workshop was mainly intended as a means of obtaining input and endorsement from a broader group of representatives from CSIRO, State agencies and producers before finalising the scoping study report.

Date and Venue

The second workshop was held on the 17th March 1998 in the Resource Sciences Centre (QDNR), Indooroopilly (Brisbane).

Participants

John Aldrick, CSIRO LW, Canberra
Chris Barnes, CSIRO LW, Canberra
Jocelyn Baker, producer,
Col Brett, producer, Charters Towers
Rosemary Hook, Land and Soil Consulting, Canberra
Judy Lambert, MLA/NAP3, Sydney
Graham Miller, producer, Rockhampton
Paul Novelly, Agric. WA, Kununurra
Ian Poiner, CSIRO MAR, Cleveland
Mick Quirk, QDPI, Charters Towers
Mark Sallaway, QDNR, Bundaberg
Kirk Smith, producer, Charters Towers
Barry Walker, MLA/NAP3, Brisbane
Andrew Ash, CSIRO TAG, Townsville
Jenny Bellamy, CSIRO TAG, Brisbane
Leith Boully, producer, Dirranbandi
Robin Bruce, QDNR, Indooroopilly
Heather Hunter, QDNR, Indooroopilly
Greg McKeon, QNDR, Indooroopilly
Chris Moran, CSIRO LW, Canberra
David Orr, QDPI, Rockhampton
Ian Prosser, CSIRO LW, Canberra
Christian Roth, CSIRO LW, Townsville
Mark Silburn, QDNR, Toowoomba
Wendy Tyrell, BHP, Brisbane
Blair Wood, NTDPLE, Palmerston (NT)

Outcomes

- following a presentation on the procedures used to achieve ranking of intrinsic vulnerability to erosion and relevance to the North Australian beef industry, the original proposed list of 6 short-listed catchments was further narrowed down to Burdekin, Burnett, Fitzroy (QLD), Ord, Victoria. These short-listed catchments were to be documented in detail and prioritised further in the final report.
- following a presentation of research issues and ideas on a conceptual framework, a lively debate was held on research and communication priorities, the outcome of which was an endorsement by the workshop of the need to focus future research onto sediment and nutrient processes at hillslope to catchment scales as related to grazing management and on-site effects;
- it was recognised that economic viability and other socio-economic determinants needed to be taken into account in the design of communication strategies;
- there was a clear recognition from the workshop participants that a comprehensive communication strategy was required to link the research components internally and externally to ongoing research elsewhere, as well as ensuring suitable producer involvement from initial stages of project development through to later phases of project management. It was agreed that this could be adequately catered for by the establishment of a steering committee.

8.4 Research proformas

Research project proforma No. 1 - NAP3 scoping study

Title of project:
Climate variability, grazing management and nutrient loss in a tropical savanna

Organisation(s) responsible (name, address, phone, fax, email):
Principal Investigator
Name: Dr Peter O'Reagain
Postal Address : QDPI Grazing Land Management Unit
PO Box 976, Charters Towers, 4820
Phone: 07 - 4787 2155 Fax: 07 - 4787 4998

Project leader/contact (name, address, phone, fax, email):
As above

Location of research:
Wambiana, 80 km S of Charters Towers

Objectives (dotpoints):
1. To quantify the effect of different grazing strategies on nutrient/soil loss in a seasonably variable tropical savanna.
2. To quantify any tradeoff which might exist between soil/nutrient loss and other variables such as animal or pasture production.
3. To develope and promote sustainable grazing strategies which assist primary producers to cope with climate variability

Expected outcomes and implications for the grazing industry (dotpoints):
1. Quantification of the effects of different grazing strategies on soil and nutrient loss in a semi-arid savanna.
2. Demonstration to producers of the comparative ability of different stocking strategies to cope with climate variability.
3. Quantification of the trade off between soil/nutrient loss and animal and pasture production.

Time lines (start, finish dates, important milestones):
Start : 1998 wet season.
Finish: 2001 or later

Funding sources:
GBRMPA, CRC, NHT and drought Regional Iniative.

Brief summary and findings to date (max. 250 words):
Equipment yet to be installed.

Summary of methods (max. 250 words):
A large grazing trial comparing the ability of different grazing strategies to cope with climate variability in terms of their effects on animal production and resource condition has been established 80 km S of Charters Towers. Trial paddocks are *c.* 100 ha in size and contain a mixture of soil-vegetation associations. Bounded runoff plots (10 by 60 m) fitted with Gerlach troughs will be established on the gently sloping brown sodosols in replicated paddocks for each of 3 grazing strategies ie light, heavy and variable stocking. Runoff rate and volume will be measured via tipping buckets. Bed load will be estimated from the amount of soil deposited in troughs while suspended sediment will be estimated from runoff samples. Detailed measurements of cover etc, will be made at representative times through the season. In one of the plots on each of the 3 treatments pumping samplers will be fitted to sample runoff water for N and P. Due to the proximity to Charters Towers it should be possible to freeze most samples within three hours of any runoff event

Research project proforma No. 2 - NAP3 scoping study

Title of project:
Development of a three-dimensional facies model for variable-discharge, tropical rivers: the upper Burdekin River, north Queensland

Organisation(s) responsible (name, address, phone, fax, email):
Dr C.R. Fielding
Dept of Earth Sciences,
University of Queensland,
Qld 4072

ph 07-3365 2373
fax 07-3365 1277
e-mail: chrisf@earthsciences.uq.edu.au

Project leader/contact (name, address, phone, fax, email):
as above

Location of research:
Burdekin River, upstream from Charters Towers

Objectives (dotpoints):
- to provide a sound geological model for deposits of tropical, variable discharge rivers
- to characterise the distribution of sediments in the surface and subsurface of the modern Burdekin River
- to document the role played by riparian vegetation in sediment transport and deposition, in the Burdekin River

Expected outcomes and implications for the grazing industry (dotpoints):
- model illustrating the distribution of different sediment types within the alluvium of the modern river, in three dimensions
- better understanding of the role of vegetation in influencing sediment depositional patterns

Time lines (start, finish dates, important milestones):
Project was funded by Australian Research Council over the period 1995-7. Project has now been concluded. Three research papers are in print, two more submitted, and two further ones in preparation.

Funding sources:
Australian Research Council

Brief summary and findings to date (max. 250 words):
The project has achieved the principal aims set out in the original proposal. The study reach of the Burdekin River northwest of Charters towers was examined exhaustively in conditions ranging from minimal flow during dry seasons to bankfull during a major flow event.

The sedimentological data have been collated into a facies model for the upper Burdekin River, fulfilling the primary aim of the project. Data from Ground-Penetrating Radar (GPR) surveys have proved critical to this analysis, with an extensive grid of survey lines providing fine detail of sedimentary architecture in the subsurface. The quality and quantity of these data vindicate the use of the technique, and offer encouragement for the potential of future projects of this nature. We carried out two GPR surveys, the first in August 1996 after a three year period of little flow, and the second in December 1997 after a bankfull flow event in March 1997. By resurveying 1996 lines in the 1997 programme, we were able to directly address the sedimentological effects of the March 1997 bankfull event. The results confirm our working hypothesis that during major flow events, parts of the river bed are stripped of alluvium down to the bedrock interface, and that sediment is then re-deposited during falling stage. These results also emphasise the importance of bankfull flow events in moulding the sedimentary fill of the upper Burdekin River, and quantify the relatively minor effects of smaller flow events.

Our data show that the alluvium in the study reach is up to c. 6 m thick, and comprises principally coarse to very coarse-grained sands and gravels, arranged into bedsets that in different places show well-developed, high-angle cross-bedding, low-angle cross-bedding and planar stratification. Finer-grained sediments are mainly confined to the vegetated portions of upper bar surfaces. The stratal geometry evident from the GPR is comparable to, but

shows important differences from, other published studies of meandering river deposits.

Another major outcome of our study is the discovery of the pivotal role played by river bed vegetation in sediment deposition and nucleating bar development. The river bed community (principally paperbark trees - *Melaleuca argentea*) survives regular, total inundation in fast-flowing water by morphological adaptations. Trees grow preferentially in flow-parallel, linear groves, and engineer their environment by deflecting currents, building sand and gravel bars and stabilising banks. This is the first study to document in-channel bar development resulting from vegetation growth, rather than the reverse which has been inferred by previous workers.

Summary of methods (max. 250 words):

In all, a total of eight field seasons and shorter visits were undertaken. The following properties of the river bed were mapped: surface topography (using a Total Station), surface sediment character (size, composition, orientation analysis), bedform distribution, *in situ* and transported vegetation distribution, hydrological characteristics, suspended sediment mineralogy, major/minor element water chemistry, and subsurface sediment distribution using cutbank exposures, trenches, auger holes and pits, and extensive Ground-Penetrating Radar data.

Research project proforma No. 3 - NAP3 scoping study

Title of project:
Erosion risk assessment of the TFTA/Dotswood

Organisation(s) responsible (name, address, phone, fax, email):
CSIRO Land and Water
Private Mail Bag No. 2
Glen Osmond, SA 5064

Project leader/contact (name, address, phone, fax, email):
Dr. Christian Roth, CSIRO Land and Water, Davies Laboratory Townsville
PMB PO Aitkenvale, QLD 4814
Tel. 07-47538569, Fax 07-47538650, christian.roth@tvl.clw.csiro.au

Location of research:
Section 7 of the Townsville Field Training Area, Dotswood

Objectives (dotpoints):
- assessment of sheet erosion in relationship to cover and surface disturbance, relying to a great extent on pedo-transfer functions obtained from intensive rainfall simulation experiments at 2-3 key sites;
- assessment of gully erosion as affected by excessive grazing pressure, on the basis of a digital terrain analysis relating key topographic attributes to rainfall and soil strength;
- assessment of gully erosion as affected by traffic intensity and road design, based on a similar approach as above.

Expected outcomes and implications for the grazing industry (dotpoints):
- an improved understanding of grazing impacts on hillslope runoff generation and sediment detachment, transport and deposition processes for key geomorphic units

Time lines (start, finish dates, important milestones):
April 1998 - March 2000

Funding sources:
Defence Department/LWRRDC/CSIRO

Brief summary and findings to date (max. 250 words):
project yet to initiate

Summary of methods (max. 250 words):
- rainfall simulation experiments to parametrise models to assess runoff generation in relation to surface condition and vegetation
- modeling of runoff flow in a GIS framework

Research project proforma No. 4 - NAP3 scoping study

Title of project:
Land management to reduce nutrient movement from catchments.

Organisation(s) responsible (name, address, phone, fax, email):
CIRM - Dr David Gramshaw
Centre for Integrated Resource Management
Hartley Teakle Building (6th Floor)
UNIVERSITY OF QUEENSLAND QLD 4072

Tele: (07) 3365 6879
Phone: (07) 3365 2965
Email: dgram@cirm.uq.edu.au

Project leader/contact (name, address, phone, fax, email):
G. Titmarsh
Department of Natural Resources
PO Box 318
Toowoomba Qld 4350

Phone: (07) 4688 1020
Fax: (07) 4688 1188

Location of research:
Queensland portion of Murray-Darling Basin.

Objectives (dotpoints):
- Quantify the levels of sediment, nitrogen (N) and phosphorus (P) in runoff and the rates of movement of water and mobile nutrients (nitrates and chlorides) below the root zone in a range of representative catchments spanning key soil types, broad land uses, dryland cropping practices and catchment sizes.
- Identify the main mechanisms driving sediment, N and P movement into streams and groundwater of a catchment and the impact of land uses and cropping practices on these.
- Produce an interactive, multi-layered (e.g. soil, topography, land use classes, fertiliser use and climate) geographic information system (GIS) for a demonstration catchment in the Upper Condamine.
- Construct and deliver a generic spatial modelling framework (SMF) using ADVISE software to interactively link the enhanced water quality and other existing models with catchment GIS's for scenario analyses and decision support applications.
- Evaluate and validate the linking of transferable water quality model(s) for catchment simulation and predictive applications
- Demonstrate the utility of the SMF by providing customised, decision support information and maps for the predominantly cropped Upper Condamine catchment which depict water quality scenarios for alternative cropping and land use practices at sub and whole catchment scales and over different weather sequences.
- Liaise at key project design and implementation stages with Murray-Darling Basin catchment coordinating groups on data collection and interpretation and on development of relevant decision support

Expected outcomes and implications for the grazing industry (dotpoints):
- Awareness of erosion/pesticide problems.
- Pesticides may be restricted in use.
- Grazing managements altered.

Time lines (start, finish dates, important milestones):
Project Start Date: 9/1994 Project Completion Date: 9/1997

Funding sources:
MDB

Brief summary on progress to date (max. 250 words):
- Drought-breaking rains in the 1995/96 summer allowed reliable sampling of a total of **189 site x runoff events**. This occurred at most of the sites (0 events at 2 sites, 1-3 events at 13 sites, 4-6 events at 13 sites and 7-10 events a 11 sites and involved moderate to high intensity rainfall events.

- Most of the sediment and water samples collected in 1996/97 summer, with other events being recorded or anticipated from the revealing weather conditions at the time of reporting.
- A digitising program and spreadsheet templates have been developed to help extract information from hydrograph charts and to assist data presentation, analysis and interpretation.
- The data so far is predictably showing that clay particles are the most significant vehicle for nutrient movement. Also indicated is a pattern of first an increase, and then a decrease, in the proportion of larger particles in runoff sediment progressively down a catchment; this may reflect mid-catchment gully and creek sidewall erosion.
- Runoff water sampling equipment (rising stage and pumping samplers) remains operational on a total of 39 sites at 14 monitoring locations extending from Toowoomba to Charleville in the northern Murray-Darling Basin.

Summary of extension approach (max. 250 words):

- One on one
- Seminars/Conferences
- Newspaper articles
- Radio/Television spots
- Workshops

Research project proforma No. 5 - NAP3 scoping study

Title of project:
Modelling sediment and nutrient sources and stores and the risk of their delivery through catchments

Organisation(s) responsible (name, address, phone, fax, email):
CSIRO Land and Water
Multi-divisional Program
Dryland Farming Systems for Catchment Care
GPO Box 1666 ACT 2601

p:6246 5926
f:62465965

Project leader/contact (name, address, phone, fax, email):
Dr C J Moran
CSIRO Land and Water
GPO Box 1666 ACT 2601

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chris.moran@cbr.clw.csiro.au

Location of research:
Wagga NSW, Burdekin North Qld

Objectives (dotpoints):
- To develop and compare distributed modelling and geomorphic summary techniques for estimating the delivery of sediment and nutrients to streams and riparian zones.
- To use spatial perturbation techniques to estimate the hazard of sediment delivery
- To estimate risk of realisation of the hazard using soil and land-use information
- To predict the effects of altering land-use on sediment delivery risk.

Expected outcomes and implications for the grazing industry (dotpoints):
- To determine hazard to water and land resources associated with sediment and phosphate mobility in response to land-use management.
- To interpret whether the identified risks, and therefore the land-uses, are acceptable in terms of the whole catchment
- Guidelines as to which zones impart significant hazard to the whole catchment in response to land-use options

Time lines (start, finish dates, important milestones):
Finishes June 30 2001

Funding sources:
CSIRO

Brief summary and findings to date (max. 250 words):
Methodology development only to date.

Summary of methods (max. 250 words):
- Estimation of properties using sampling based on terrain analysis and spatial interpolation
- Estimation of hazard using digital elevation models and application of spatially-distributed flow equations to define delivery of sediment and nutrient to channels.
- Estimation of risk of sediment and nutrient delivery using field measurements and land-use scenario modelling combined with spatial patch optimisation, i.e., determining the patch size and location distributions to provide management options that optimise land use suitability and minimise sediment and nutrient transport risk.

Research project proforma No. 6 - NAP3 scoping study

Title of project:
Nutrient and sediment delivery from the Herbert River

Organisation(s) responsible (name, address, phone, fax, email):
CSIRO Land and Water

Project leader/contact (name, address, phone, fax, email):
Dr Chris Barnes,
CSIRO Land and Water,
GPO Box 1666,
CANBERRA, ACT 2601

Phone: 02 6246 5808
Fax: 02 6246 5800
Email: chris.barnes@cbr.clw.csiro.au

Location of research:
Herbert River catchment, Queensland

Objectives (dotpoints):
- To quantify the fluxes of major nutrients (N and P) from the Herbert River Catchment to the Great Barrier Reef (GBR) lagoon; and to identify significant interactions between, and the relative importance of, the major factors (climate, soil type, land use etc.) influencing these fluxes.
- To identify current and potential management practices which may affect the temporal and spatial distribution of these fluxes, and their magnitudes.
- To provide this knowledge in a form suitable for encapsulation in a Decision Support System (DSS), for use by stakeholders in the Herbert River region.
- To develop modelling techniques which utilise measurable landscape and system properties (eg stream network topology), rather than point parameters (eg hydraulic conductivity) to describe system behaviour at a range of scales.
- To distinguish between purely local influences, and those of a more generic nature, in order to maximise the potential for transferring the developed analytical processes to other catchments.

Expected outcomes and implications for the grazing industry (dotpoints):

Time lines (start, finish dates, important milestones):
June 1995 - June 1998

Funding sources:
CSIRO

Brief summary and findings to date (max. 250 words):
- A sampling network has been set up to monitor water quality and quantity, including turbidity and stage height. There are four main sampling sites and the Herbert catchment is subdivided into four main regions using this strategy: the upper Herbert; the lower Herbert above the Stone River confluence; the Stone River Catchment; and the lower Herbert below the Stone River confluence. Each area has appreciably different climate, soils, and land usage, and the aim of the monitoring is to look for significantly different responses from different areas (in terms of sediment and nutrient production), and where such differences are identified, to attempt to relate them to the above factors.
- Equipment at monitoring sites (samplers, turbidity meters, pressure transducers and data loggers) has been duplicated, in an attempt to increase the reliability of data collection in this relatively hostile environment.
- A monitoring site on cane land has been established using small flumes on adjacent plots of fallow and productive land (see. This site is intended to characterise sediment and nutrient production from this particular land use. Approximately 20 additional stream sites are also being sampled for stream chemistry and sediment concentration, in order to characterise the range of variation in concentrations and loads across the catchment, and to indicate areas which need further investigation. (See project on effects of rural land use)

Summary of methods (max. 250 words):
In assessing nutrient and sediment delivery from the catchment, prime questions relate to: the production rate of sediment and nutrients from various combinations of land use/soil type/climate; the contribution from each combination to the local stream network, and to the GBR lagoon; and whether it is possible to discern an anthropomorphic effect on measured concentrations and loads. Answering these questions requires the development of a methodology to relate input and output measurements at different scales, and initially at least, the analysis will be carried out from determining residence time distributions for the various materials, and what affect, if any, different management strategies might have on production rates and these distributions. On a more theoretical note, the project will attempt to identify catchment scale parameters related to production, storage and material velocities which allow an efficient description of catchment response. In some ways, this approach is similar to the Unit Hydrograph approach of engineering hydrology, except that we are concerned with a parameterisation of the residence time distribution in terms of observable catchment properties.

A major problem in the present design is due to the expected dependence of material transport in the Herbert on extreme (and hence rare) events. It is intended to develop an additional program of field sediment sampling to characterise the historical and spatial distribution of sediments, using a variety of tracers and analytical techniques (ICPMS, radio-emitter spectroscopy etc.) to complement and supplement the stream sampling program, and to add to the work being done by AIMS in the near-shore region of the GBR lagoon.

Research project proforma No. 7 - NAP3 scoping study

Title of project:
Paddock scale guidelines for salinity management in the Balfes Creek catchment

Organisation(s) responsible (name, address, phone, fax, email):
Dept. of Natural Resources
80 Meiers Road
INDOOROOPILLY Q 4068
Phone: (07) 3224 2149, Fax: (07) 3221 9312

Project leader/contact (name, address, phone, fax, email):
Dr. Ian Gordon, DNR
address as above
Phone: (07) 38969471 Fax: (07) 38969591, email: ian.j.gordon@dnr.qld.gov.au

Location of research:
Balfes Creek Catchment, 40km west to southwest of Charters Towers

Objectives (dotpoints):
- To undertake a preliminary desktop study (using existing water balance models and datasets) that will identify the impacts of various land management strategies on recharge for the range of land types in the Balfes creek catchment;
- Using the results of the preliminary study, select sites that have been identified as "high risk" areas for strategic field measurement of soil physical properties that will permit more detailed analyses of the impacts of land management on dryland salinity and erosion;
- To develop a methodology (information delivery package) to allow the property managers to implement vegetation management strategies at the paddock scale which will minimise salinity risk in the Balfes Creek catchment.

Expected outcomes and implications for the grazing industry (dotpoints):
- A framework for integrating current knowledge and understanding of salinity risk in the Balfes creek catchment. This will have application to salinity risk assessment in other catchments in North Queensland.Property maps and resource data sets for improved property management planning.
- An assessment of potential salinity risk under various management scenarios for the catchment.
- Improved knowledge and understanding of the impact of vegetation management on catchment water balance.
- Improved understanding by property managers of key soil types and implications for management (including pasture production, erosion, and salinity).

Time lines (start, finish dates, important milestones):
July 1997 - June 1998

Funding sources:
LWRRDC, NDSP, CSIRO

Brief summary and findings to date (max. 250 words):
- Water balance simulations with Perfect are indicating great variation of drainage over different years, as function of rainfall and grass utilisation. There are also significant variations between soil types.
- Property mapping is a potential means of facilitating the transfer of salinity guidelines to scales relevant to grazier's management decisions.
- Additional soil hydrological characterisation of Yellow Earths is required to fully assess their importance in either recharge or discharge. More detailed field work is ongoing.
- There is a paucity of information on root data, imposing sa great deal of uncertainty on the water balance modelling.

Summary of methods (max. 250 words):
- Collate existing soils, geology, groundwater, vegetation, plant water use and other available resource data sets for the Balfes creek catchment and the Dalrymple shire
- Preparation of property maps and integration of resource data into property management planning workshops to allow producers to delineate and gain an understanding of available resource data at the paddock level
- Undertake broad scale water balance modelling (PERFECT, SALF, or SODICS) to evaluate the impact of various land management strategies on deep drainage and catchment water balance using existing data sets

- Establish key field sites for detailed measurement of soil physical properties, salt concentration profiles and plant water use at locations identified as "high risk" by broad scale modelling. This data is important for model validation and further refinement
- Undertake scenario analysis on key field sites (SWIM2) to evaluate the impact of pasture/tree management on water balance. This will allow development of simple rule-based guidelines related to the impact of management on water balance for major soil types within the Balfes creek catchment
- Develop guidelines for major soil types, integrating outcomes of modelling exercises with current knowledge of soil, vegetation, groundwater and landscape processess. These guidelines will also provide insight into potential impact of management options on water balance at the paddock and catchment scale
- Integrate guidelines into property management planning workshops

Research project proforma No. 8 - NAP3 scoping study

Title of project:
Sediment history of the Herbert River floodplain

Organisation(s) responsible (name, address, phone, fax, email):

Project leader/contact (name, address, phone, fax, email):

Prof. Bob Wasson
Department of Geography
School of Resource Management and Environmental Science
Australian National University
Canberra ACT 0200

Phone: (02) 6249 2706
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Dr. Jon Olley
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GPO Box 1666
ACT 2601
Canberra

(02) 6246 5826

Jon.Olley@cbr.clw.csiro.au

Location of research:
Herbert River, Queensland

Objectives (dotpoints):

- To determine the total quantity of sediment and particulate P deposited on the Herbert River floodplain.
- To determine if the post-European settlement rate of P and sediment deposition has increased, and if land use change within the post-settlement period is detectable in the sedimentary record.

Expected outcomes and implications for the grazing industry (dotpoints):

Time lines (start, finish dates, important milestones):

Funding sources:
ANU, CSIRO

Brief summary and findings to date (max. 250 words):

Summary of methods (max. 250 words):
Methods include:

- creating a material budget for the Herbert fan-delta, including modern material fluxes, deposits in the alluvial area, and in the mangrove and other coastal areas.
- determining the sensitivity of the Herbert River and fan-delta to climate change by examining the pre-European Holocene alluvial record in conjunction with independent reconstructions of past climate.

Research project proforma No. 9 - NAP3 scoping study

Title of project:
Sources and delivery of suspended sediment and phosphorus to Australian Rivers
Part A: radionuclides and geomorphology

Organisation(s) responsible (name, address, phone, fax, email):
CSIRO Land and Water,
GPO Box 1666,
CANBERRA, ACT 2601

Project leader/contact (name, address, phone, fax, email):
Mr Peter Wallbrink
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Dr Cathy Wilson,
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Address as above

Location of research:
Berner's Creek, North Johnstone River, Qld

Objectives (dot points):
- Quantify the relative contributions of topsoil and subsoil to the suspended sediment loads in generic landform/land use catchments using the atmospherically-derived land use radionuclides (^{137}Cs; ^{210}Pb, ^{7}Be).
- Link radionuclide results to trace element and radionuclide data collected by C. Martin defining the natural and anthropogenic sources of phosphorus.
- Assess the relative and absolute magnitudes of the anthropogenic and natural fluxes of phosphorus within the generic catchments. Relate the fluxes to land use and geologic and geomorphic variability in catchments.
- Develop a catchment methodology which uses catchment geomorphology to estimate the dominant sources of sediment and phosphorus, and the efficiency of delivery from sources to streams at the farm scale.
- Present this information in a form useful to regional Landcare and community groups, and to State and Federal agencies.

Expected outcomes and implications for the grazing industry (dot points):
Experimental work is not being carried out within a northern Australian grazing environment. The results, however, will be useful in that they will provide further information on the importance of gully/channel erosion in the contribution of sediment and phosphorus to some river systems. Another relevant outcome is the development of techniques to estimate sediment delivery at the paddock scale — this type of information is necessary for the effective management of nutrient delivery to waterways.

Time lines (start, finish dates, important milestones):
January 1997 to December 1999

1. 15th June, 1997
- Framework for sampling strategy
- Description of type subcatchments
- Description of sampling sites
- Framework for linking geomorphic analyses with tracer data
- Communication and technology transfer plan developed
- Samples collected from Berner's Ck

2. 15th December, 1997
- First sampling complete in Namoi subcatchments
- Preliminary conclusions regarding dominant sources of sediment in Berner's Creek catchment and the role of landscape form, drainage network and vegetation characteristics in the sediment delivery process.
-

3. 15th June, 1998
- Link P source data to sediment tracing data for Berner's Creek catchment

- Develop P source diagrams for Berner's Creek catchment showing how land use, fertilizer management and catchment erosion mechanisms influence the relative proportions of P sources.

4. 15th December, 1998
- Summary of tracer, geochemical and soil physical data showing values in relation to catchment geomorphology and land use.
- Completion of project workshop to review research findings and plan outcome delivery.

5. 15th June 1999
- All tracer and geomorphic analyses complete
- Development of P source estimates in the Namoi subcatchments

6. 15th December 1999
- Final report submitted to LWRRDC containing generic methodologies for estimating dominant sources of P and sediment in catchments from landscape features, land use and fertilizer management parameters.
- Final project workshop complete.
- List of publications in preparation or published.

Funding sources:
National Eutrophication Management Program (LWRRDC), CSIRO and NSW Department of Land and Water Conservation

Brief summary and findings to date (max. 250 words):

Summary of methods (max. 250 words):
Hypotheses being tested
- if density of exposed channel/gully > 1 km/km^2 then these will be dominant source of sediment and P in a catchment;
- total surface area of exposed stream/gully bank controls sediment and P delivery from these sources, not just drainage density;
- amount of gully derived P entering streams depends on degree of connectivity of gullies to streams as well as gradient of the gully network;
- stream sediment and P derived from cultivated lands will increase in catchments with high hillslope gradients and narrow valley floor or floodplain width;
- application of fertiliser P will increase the proportion of surface sources of P most in ungullied cultivated land and least in gullied pasture. Largest loads of P will come from cultivated, fertilised and gullied catchments.

Methods
- Geologic, geomorphic, soil and land use information will be used to identify sampling sites which ideally will cover the suite of land use and fertilizer combinations necessary to give distinct tracer signals;
- major soil types in the catchment will be sampled;
- landscape attributes likely to be strong predictors of whether surface or subsoil sources of sediment predominate in a catchment will be measured from digitised high resolution and normal air photographs and topographic maps. Attributes include drainage density, gully density, channel stability and area of exposed bank.

Research project proforma No. 10 - NAP3 scoping study

Title of project:
Bological and economic consequences of managing water-point distribution in rangelands

Working Title: Biograze: waterpoints and wildlife

Organisation(s) responsible (name, address, phone, fax, email):
- CSIRO Wildlife and Ecology, Centre for Arid Zone Research, Alice Springs (contact Craig James — details below)
- Parks and Wildlife Commission of the Northern Territory, Po Box 496, Palmerston, NT 0831 (contact John Woinarski — 08 8944 8463)
- South Australian Department of Environment, Heritage and Aboriginal Affairs, GPO Box 1047, Adelaide, SA 5000 (contact Rodger Tynan — 08 8204 8865)

Project leader/contact (name, address, phone, fax, email):
Craig James, CSIRO, PO Box 2111, Alice Springs, NT 0871. (W) 08 89500157; (FX) 08 89529587; Email: c.james@dwe.csiro.au

Location of research:
Barkly Tableland, NT and Commonwealth Hill, SA

Objectives (dotpoints):
- To quantify the impacts of the provision of artificial watering-points on rangeland biodiversity at regional scales;
- To simplify taxonomic approaches to the assessment of regional biodiversity by : (i) identifying a set of "focal taxa" that are both cost-effective to sample and representative of a wide range of habitats and niches; and (ii) classifying species into "indicator response types" based on biological characteristics and response to disturbance;
- To develop example scenarios where stocking rates or the number of water points are modified to increase the area of land available for conserving grazing-sensitive species;
- To provide stakeholder groups with an indication of the likely net costs of pursuing ecologically sustainable rangeland management integrated with off-reserve conservation in grazed rangelands.

Expected outcomes and implications for the grazing industry (dotpoints):
- Biological data on the effect of grazing and waterpoints on the biota, and example scenarios for how conservation of the biota may be integrated into management of a pastoral landscape;
- Demonstration of the order-of-magnitude of costs associated with the integration of conservation and pastoralism;
- Demystification of the expectation that the pastoral community has as to the cost and inconvenience associated with conservation (ie many still believe that conservation = national parks and is therefore a threat to livelihoods)

Time lines (start, finish dates, important milestones):
Project to run 1 May 1997 to 30 April 2000. Field work and biological survey to be completed in second year; regional scenarios and economic costings in third year.

Funding sources:
LWRRDC and Environment Australia (still pending)

Brief summary and findings to date (max. 250 words):
Progress in first year stalled due to delay in negotiating funding from EA. Future scope of work still unclear until joint funding from EA is confirmed. Work in the first year has been on response groups using data from previous surveys; preliminary field reconnaissance of SA region; completing biological survey for Barkly Tableland region

Summary of methods (max. 250 words):
Field survey

We will survey within a region (e.g., 200 x 300 km) for plants, birds and ants We will sample 10 sites in each distance-from-water class to derive a statistically reliable estimate of the distribution and abundance of species. Plant specimens will be collected so that identifications can be verified against herbarium voucher specimens. Ants will be pit trapped, sorted to morphospecies by trained para-taxonomists, and subsequently identified to species by an expert taxonomist. Birds will be identified in the field. We will use a two-stage procedure to

identify Increaser, Neutral and Decreaser response groups by their changes in abundance in relation to distance from water.

Indicator response types
For plants, we will describe traits and use multivariate analysis to characterise the biological attributes of Increaser and Decreaser plant species. By starting with an explicit recognition of the differences among plant life forms and developing different lists of traits for different life forms, this approach aims to differentiate response types within life forms. Functional group development for ants will explore morphological sub-generic differences at the level of species-groups.

Scenarios for regional conservation goals
The approaches we will analyse for both study regions are: 1. a small number of large unwatered areas; 2. a large number of small unwatered areas distributed as cheaply as possible without regard to spatial connectivity; 3. unwatered areas designed for maximal connectivity but with no size constraints; 4. controlled grazing areas (totalling X% of the district) located as cheaply as possible; 5. controlled grazing areas located for maximal connectivity. The general method is to allocate a cost of management by different means to each realistic paddock in the district and then to search for the most cost-efficient implementation of management which meets the management criteria.

Research project proforma No. 11 - NAP3 scoping study

Title of project:
Determinants of land degradation in the wet/dry tropical savannas

Organisation(s) responsible (name, address, phone, fax, email):
CSIRO Division of Wildlife and Ecology,
PMB 44,
WINNELLIE, NT 0821

Project leader/contact (name, address, phone, fax, email):
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PMB 44,
WINNELLIE, NT 0821
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dick.williams@terc.csiro.au

Location of research:
Transect Darwin - VRD

Objectives (dotpoints):
- Define the relationships between soil type, terrain and mean annual rainfall, savanna composition and structure;
- Apply low, medium and high frequency defoliation regimes to grass layer and measure vegetation and soil surface responses;
- Assess risk of savannas under different rainfall/soil conditions to degradation.

Expected outcomes and implications for the grazing industry (dotpoints):
- Understanding of determinants of perennial grass abundance, biodiversity and resource allocation;
- evaluation of use and effectiveness of soil surface characters as indicators of savanna state;
- improved understanding of state and transition

Time lines (start, finish dates, important milestones):
Commenced 1994
Completion due end of 1998 with continuation through the Savanna CRC

Funding sources:
Land and Water Resources Research and Development Corporation

Brief summary and findings to date (max. 250 words):
- Reasonably predictable relationship between rainfall and soil texture and tree cover, grass basal area and community composition;
- nutrients concentrated into rich patches in landscape, associated with patches of perennial grass. Inter-patch areas poor in nutrient quality.
- changes in cover and basal area of perennial grasses linked to changes in soil surface indicators of ecological change.
- soil surface indicators of savanna state have potentially wide applications in northern Australian rangelands.

Summary of methods (max. 250 words):
- reference sites at key locations along rainfall gradient in NT (1600 mm—380 mm pa);
- 3 soil types at each site (vertosol, kandosol, tenosol);
- 1 ha reference plots, geolocated at each rainfall/soil site;
- measurement of suite of savanna characteristics - vegetation structure, composition and patchiness; soil texture, depth and surface condition; invertebrates, vertebrates.
- Some sites with high resolution images — SPOT/RADAR
- disturbance regime applied to 3 soil types @ 5 rainfall locations: ungrazed, grazed at ambient stocking rate; clipped frequently (5-6 times) during wet season.
- measurement of responses to rainfall, soil texture and disturbance of perennial grass cover, basal area and soil surface condition.

Research project proforma No.12 - NAP3 scoping study

Title of project:
Developing sustainable beef production systems for the semiarid tropics of the Northern Territory

Organisation(s) responsible (name, address, phone, fax, email):
Northern Territory Department of Primary Industries and Fisheries

Project leader/contact (name, address, phone, fax, email):
Rodd Dyer,
Katherine Research Station,
NT Department of Primary Industries and Fisheries,
PO Box 1346,
KATHERINE, NT 0851

Phone: (08) 8973 9750
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Location of research:
Katherine, VRD and Sturt Plateau Regions, NT

Objectives (dotpoints):
To ensure, for the VRD and Sturt Plateau regions, that by 2001:

- more than 65% of pastoral land managers have an increased understanding and knowledge of local pasture communities and basic grazing ecology and management;
- that 50% of pastoral managers have investigated the economic viability of a range of sustainable grazing management options using a range of Decision Support Systems in a whole-property framework;
- 60% of pastoral properties have documented current paddock and property stocking rates and developed individual estimates of sustainable livestock carrying capacity;
- 70% of producers are aware of the principles and best practice of controlled burning by providing a relevant and practical fire management manual and presenting information at on-property workshops, field days and shows;
- that the majority (>80%) of land managers and administrators are aware of the increase, cause, impact and potential cost of unchecked woody plants;
- that 50% of pastoral leases have developed or implemented strategic grazing management plans as a result of active participation in whole paddock demonstrations of sustainable grazing management options.

Expected outcomes and implications for the grazing industry (dotpoints):
Improved pasture management

Time lines (start, finish dates, important milestones):
July 1996 to June 2000

Funding sources:
MRC NAP3 program

Brief summary and findings to date (max. 250 words):
The emphasis of this project in NAP2 was the development of effective burning strategies, understanding the competitive relationships between trees, shrubs and pastures and the development of pasture growth models that can be used to investigate the stocking rates and carrying capacity. The first phase of the project involved extensive collection of data. Continuing work will focus on incorporating available data and information into simple management guidelines that fit into whole property management.

Summary of methods (max. 250 words):
To ensure effective development and implementation of sustainable grazing management practices, several approaches will be taken in six new subprojects. Together these projects will produce a range of products providing information to land managers in a simple and effective manner. Significant work will be undertaken on-property with individual managers in order to capture and record producer knowledge and experience, and provide a cooperative approach to investigating relevant economic and management scenarios at a realistic property level. The power of GIS, land unit mapping, pasture growth models (GRASP), complete herd and enterprise models (RANGEPACK HerdEcon), and climate (RAINMAN) decision support systems will be utilised to enhance the analysis and presentation of information at a landscape scale and in a whole property context. Finally, the

establishment of demonstration paddocks on several commercial properties aims to promote the development of sustainable grazing management plans by individual pastoralists through group learning.

The project will:

- produce an information booklet on native pastures and their management;
- provide economic assessment of grazing management options;
- record current stocking rates and provide estimates of sustainable carrying capacities at a land type and paddock level;
- produce an information booklet on practical fire management for pasture management and woody plant control;
- investigate the impact of woody vegetation on carrying capacity;
- use grazing demonstrations at the property level to encourage group learning and promote sustainable grazing practices.

Research project proforma No. 13 - NAP3 scoping study

Title of project:
Effects of stocking rate, legume augmentation, supplements and fire on animal production and stability of native pastures

Organisation(s) responsible (name, address, phone, fax, email):
Queensland Department of Primary Industries
Tropical Beef Centre
PO Box 5545
Rockhampton Mail Centre Q 4702

Phone: 07 49238100 Fax: 07 49238222

Project leader/contact (name, address, phone, fax, email):
Dr Bill Burrows, DPI TBC, PO Box 5545 Rockhampton Mail Centre 4702

Phone: 07 4923 8100 Fax: 07 4923 8222 email burrowb@dpi.qld.gov.au

Location of research:
"Galloway Plains", Calliope, Central Queensland.

Objectives (dotpoints):
- Asses the productivity and stability of native pastures grazed at a range of stocking rates, with or without the addition of legumes, supplements and fire
- Determine the animal production and economic consequences of grazing under each of the treatments and relate performance to pasture characteristics
- Integrate the results into a sustainable management package for producers
- Incorporate results from this study using GRASP to determine optimum stocking rate and economic performance for commercial beef enterprises in the black speargrass region

Expected outcomes and implications for the grazing industry (dotpoints):
- Demonstration that long term sustainability and financial viability is achievable through the adoption of conservative stocking rates.
- Increased understanding of the dynamics of stocking rates, legume augmentation and fire in native black speargrass pastures.

Time lines (start, finish dates, important milestones):
Funding commenced 1987 under NAP1, continued under NAP2 (1992-1996) and is currently funded until June 2001.

Funding sources:
Meat Research Corporation NAP3

Brief summary and findings to date (max. 250 words):
- There has been a clear response in total runoff, peak runoff and soil movement with all increasing with increasing stocking rate.
- Pasture yields have varied between years but show a consistent decline with increasing stocking rate.
- Considerable variation in pasture composition has occurred due to climatic variation but permanent changes in pasture composition have not been established.
- Changes in density of *Heteropogon contortus* are apparent in permanent quadrats where density has increased at light stocking rates.
- Changes in the basal area of *H. contortus* reflect similar changes in species composition measured by Botanal.
- Slow but inexorable increase in Seca stylo density across all oversown treatments with the fastest increase at the lightest stocking rate.
- There is a significant effect of stocking rate on the performance of animals grazing native pasture (mean 'a' values of 158 and 'b' values of -99 over eight drafts where y=a-bx and y=Liveweight gain / head and x= steers / ha).
- A large range in production per head has resulted from seasonal variation.
- Oversown legumes enhance livestock performance (Mean 'a' values of 215 and 'b' values of -161 over eight drafts).

- There is a significant correlation between pasture legume content and animal liveweight gain of animals grazing legume oversown native pastures.
- Diet selection studies highlight the positive selection for legume in the autumn - winter period.
- The proportion of total legume and legume leaf content of diet extrusa declined markedly when stocking rates increased from 4 to 2 ha / head.
- Systems studies show it is feasible to produces reliable predictive models of animal liveweight gain from native pastures but these models were unable to predict liveweight gain from legume oversown native pastures.

Summary of methods (max. 250 words):

- Pasture yield and composition measured each 6 months using BOTANAL.
- Dynamics of *Heteropogon contortus* monitored annually in permanent quadrats.
- Germinable seed banks determined from soil cores collected annually in spring.
- Total perennial grass basal area is monitored each second year using a wheel point.
- 'QGRAZE' pasture monitoring sites were established in all paddocks in 1992.
- Rainfall, runoff and soil loss are measured in plots established in the exclosure, 0.25 and 0.5 beasts / ha treatments.
- Rainfall, infiltration and runoff parameters are determined using a rotating disc rainfall simulator.
- Soil pore size distribution is measured using a disc permeameter.
- Animal production is measured as the growth of crossbred steers.
- Estimates of the stocking rate effects source are made with steers fistulated at the oesophagus. Extrusa is described by a microscope point hit technique.
- Incorporate results into GRASP model to parameterise the model for the experimental site.
- Economic analysis on the main treatment results.

Research project proforma No. 14 - NAP3 scoping study

Title of project:
NAP3.208 - "Enhancing Pasture Stability and Profitability for Producers in *Aristida / Bothriochloa* Woodlands."

Organisation(s) responsible (name, address, phone, fax, email):
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Department of Primary Industries, Queensland
PO Box 6014
ROCKHAMPTON MAIL CENTRE QLD 4702

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Project leader/contact (name, address, phone, fax, email):
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Location of research:
Injune and Rubyvale

Objectives (dotpoints):
- Describe the productivity and ecological dynamics of 2 major subtypes of the *Aristida / Bothriochloa* pasture type by February 2001, with particular reference to the impact of climate and common management practices such as grazing pressure, clearing and fire.
- Develop practical grazing management packages by June 2001 which are economically viable and ecologically sustainable for *Aristida / Bothriochloa* pastures in Central Queensland.
- Communicate evolving and existing native pasture management knowledge to primary producers, resource managers and the general community according to the timetable outlined in the project milestone schedule.

Expected outcomes and implications for the grazing industry (dotpoints):
1. Good level of scientific understanding of the pasture dynamics of the main pasture units.
2. Practical grazing management systems to allow economically sustainable use of A/B pastures.
3. Several core groups of producers with a clear appreciation of the main factors that they can manipulate to produce the best long term commercial outcome for them.
4. Widespread group of graziers throughout southern and central Qld with a working knowledge of the identity and adaptability of key pasture species.
5. Quantified relationships between grazing pressure and the pasture, tree and landscape resources of two key management units in the Fitzroy Basin and adjacent parts of the Burdekin and Murray-Darling Basins.

Time lines (start, finish dates, important milestones):
Began Oct 1992 Ends NAP3 phase June 2001

Objective 1

a. Provide biennial reports on pasture species dynamics under 3 grazing intensities, extremes of tree density and spring burning at the 2 focal trial sites [Aug 1998, Aug 2000].
b. Provide biennial reports on runoff and sediment movement under 3 grazing regimes [October 1997, July 1999].
c. Provide triennial reports on woody plant growth and regeneration in all treatments [November 1997, November 2000].
d. Produce a final published report on the core trial results by 30 June 2001 and an earlier model that predicts production sustainability using GRASP and current hydrological models [February 2001].

Objective 2

Hold a workshop in September 1998 with Dept Environment, Dept Natural Resources, Universities, CSIRO, RIRFs, selected producers etc. to work through topics impinging on sustainable grazing resource management. The booklet 'Management of *Aristida/Bothriochloa* Pastures' is to be published by Ian Partridge by Dec 1998, containing ideas gleaned from this workshop.

A report from the workshop will be produced by 30 Nov 1998, centering on
- Grazing interactions with key wildlife species,
- Landscape stability in Central Qld highlands,
- Indicators of financial viability, and

- Integrated property and resource management.

Objective 3

a. Hold a field day in May each year to review progress and involve producers in discussions about a topic decided by the focal site consultative committees.

b. Implement the proactive communications package agreed to with MRC.

Funding sources:

Meat Research Corp, QDPI and DNR

Brief summary and findings to date (max. 250 words):

- Eucalypt seed loads in the soil in the last 3 years have been negligible.
- Moderate grazing pressure (50% use of April fodder over the next year) produces as much beef as heavy (75%) utilisation.
- Removal of poplar box at Injune allows pasture growth to double but at Rubyvale the improvement has been minor to date.
- Blackspear grass is a very dynamic pasture component at Rubyvale on granite soils.
- Clearly separable pasture types are difficult to proscribe any more readily than that now based on dominant trees or great soil group.
- Stable vegetation states are not the norm in eucalypt woodlands in the region. All states revert to a woodland with a variable degree of shrub understorey.
- Suspended sediment load carried away in runoff is often of a similar magnitude to the more visible bedload redistributed short distances locally.

Summary of methods (max. 250 words):

Native pastures growing under trees or on cleared country are continuously grazed at 3 grazing pressures. Similar ungrazed areas are burnt each spring when fuel permits. The overstorey trees are poplar box at Injune and silverleaf ironbark at Rubyvale.

Pasture species dynamics are measured at various spatial scales using annual BOTANAL surveys for paddock botanical composition, measuring changes in plant basal area by the point frame method along fixed lines and charting of fixed quadrats plus annual spring sampling of soil seed loads in the same area.

Instrumented Gerlach troughs and micro-catchments on a subset of the grazed paddocks provide data on runoff and soil movement.

Tree and shrub growth and regeneration are measured along fixed transects using the TRAPS methodology.

Cattle are weighed regularly along with a mob of 15 head in an adjacent area which is managed the same as the moderate grazing pressure treatment.

Collaborative activities with the two advisory groups will continue on a regular basis. They have a critical role in assisting to develop management packages and also in evaluating/testing some of the recommended practices.

A wider participation of project team members with industry will be achieved via their attendance/speaking roles at industry seminars and workshops convened by other agents and other initiatives such as QA, Bestprac, Landcare, PMP, Natural Heritage Trust and NAP3 promotions.

Research project proforma No. 15 - NAP3 scoping study

Title of project:
Environmental Management of Military lands in Tropical Savannas
Organisation(s) responsible (name, address, phone, fax, email):
CSIRO Tropical Agriculture, PMB Aitkenvale, QLD 4814 and QDPI, PO Box 876, Charters Towers, QLD 4820

Project leader/contact (name, address, phone, fax, email):
Andrew Ash, CSIRO Private Mail Bag, Aitkenvale, QLD 4814, Ph 07 47538540 Fax 07 47538600 Email: Andrew.Ash@tag.csiro.au

Location of research:
Townsville Field Training Area, 60 km west of Townsville in the Burdekin catchment.

Objectives (dotpoints):
By December 1999 to:
1. Examine the long term impacts of livestock grazing, fire and army training practices on land condition and determine how those disturbances can be integrated into a plan to achieve vegetation objectives;
2. Prepare a detailed land suitability assessment of the TFTA defining critical management areas (ie erosion risk, endangered vegetation types)
3. Develop a qualitative model of the impacts of common forms of disturbance impact soil and vegetation combinations
4. Develop indicators of vegetation and soil changes that can be used by managers as a basis for decisions about timing and intensity of disturbances
5. Assess the value of Land Condition Trend Analysis (and alternative methods) for monitoring land condition and trend and as a basis for decision making
6. Validate the applicability of remotely sensed imagery as a tool for managing vegetation at community and landscape scales

Expected outcomes and implications for the Military (dotpoints):
1. A GIS based land capability map of TFTA defining critical areas for management
2. A handbook (and if appropriate computer software) that can be modified for other training areas in Tropical Savannas
3. Guidelines for sustainable management of savanna training areas that include a wide range of values
4. Recommendations on the extent to which livestock grazing can be incorporated into management of training areas

Time lines (start, finish dates, important milestones):
Start date: January 1 1997, End date: December 31 1999.
Funding sources:
LWRRDC, Department of Defence, CSIRO
Brief summary and findings to date (max. 250 words):
As an agency of the Commonwealth Government, the Defence Department is committed to maintaining the environmental values of Defence Department properties while achieving their primary objective of providing high-quality, effective training to maintain defence force readiness. The Townsville Field Training Area represents a particular management challenge in that it is intended to be used heavily for a variety of military training activities and the Defence Department has agreed to maintain the existing land use (livestock grazing) at least until 2000 on Dotswood property.

The integration of these two objectives (quality military training and ecological sustainability) represents a substantial challenge for an organisation that traditionally has not focussed on land management. Developing and implementing a successful land management program will require a) efficient collection, processing and presentation of relevant data with high information content:cost ratios, b) integration of that data into decision support tools that create an environment that encourages land managers to explore opportunities for improving both training operations and land management and c) commitment of Defence Force personnel.

Summary of methods (max. 250 words):
Project 1: The use of satellite imagery is especially attractive to land managers because it is relatively inexpensive and offers the ability to compare current land condition to historical patterns of land use and management. This project will develop a history of the patterns of land use on both Dotswood and High Range Training Area, focussing specifically on the disturbance of ground cover over the past 25 years. The results of this effort will determine to what extent remotely sensed imagery can be used as a tool by decision makers to diminish the impact of training activities in the future.

Project 2: The most appropriate methodology to determine the current impacts and to predict the impacts of future decisions on the environment of TFTA will be by the use of ground-based sampling. At the plant community scale, areas of known history will be sampled for plant and animal species diversity, soil condition, plant cover. In particular, contrasts of military training, grazing and unused areas will be sought out for comparison.

At the catena scale, we will compare military training, livestock grazing and protection in terms of impact on riparian conditions (tree cover, streambank damage, herbaceous cover, wildlife habitat etc) and on the impact on water quality. Riparian conditions will be determined by large plot techniques. Water quality will be determined by the use of catena gauging stations.

Project 3: Information from Priority Area 1 will provide information about both the tolerance of land to degradation as a result of military training and livestock grazing and what kind of measurements are most appropriate for monitoring sustainability. However, the primary mission of the Defence Force is to provide training to soldiers. Military land use, like most other extensive land uses, is relatively inefficient in exploiting resources. As a result, overuse occurs in some areas and other ares are under used. This project will develop a procedure that land managers can use to match training requirements with land resources to provide high-quality training exercises.

Project 4: This focus of this project will be the construction of a Geographic Information System (GIS) that includes soils, topography, vegetation and infrastructure. The LANDASSESS decision support software will be used to develop State and Transition models for each major land type. Information from field experiments and observations (Projects 1-3) will be integrated into the software to define the spatial distribution of disturbance associated with training and grazing activities. Criteria for maintaining vegetation in the current state will be specified by land type. Using the constraint satisfaction approach, carrying capacities for individual management units will be calculated and scenarios can be evaluated. The GIS will also be adapted to graphically display alternatives for training activities.

Research project proforma No. 16 - NAP3 scoping study

Title of project:
Incorporation of practical measures to assist conservation of biodiversity within sustainable beef production

Organisation(s) responsible (name, address, phone, fax, email):
CSIRO Tropical Agriculture

Project leader/contact (name, address, phone, fax, email):
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306 Carmody Road,
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Location of research:
Crows Nest, Auburn R. areas (Burnett Catchment)

Objectives (dotpoints):
The broad scientific and communication goals of this project are, by June 2001, to:

- significantly advance conceptual understanding of the relationships between the grazing of cattle and grazing management, and the conservation of regional biodiversity within the complex landscapes of the north;
- quantify these relationships for at least one ecosystem that is economically important to the northern beef industry;
- link these quantified relationships to measures of productivity, and thence to economic indicators of enterprise returns, and assess alternative management strategies for both economic and biodiversity costs and benefits;
- identify practical measures to conserve biodiversity that producers can incorporate within sustainable management practices, together with simple indicators they can use to assess results and continue to adapt and improve management;
- assess whether the results of this project can be used to assist management for conservation of biodiversity in other ecosystems in northern Australia;
- proactively publicise and disseminate project results to the industry and others concerned with natural resource management in northern Australia, including providing assistance to producer-led management within NAP3.

Expected outcomes and implications for the grazing industry (dotpoints):
Expected outcomes include:

- a learning module for producers introducing concepts of ecological sustainability and biodiversity conservation in a whole property context;
- a manual providing appropriate technical information for producers and other resource managers wishing to implement sustainable management;
- 100 beef producers in northern Australia implementing management strategies on their properties to maintain biodiversity and sustainability;
- at least 500 beef producers demonstrating awareness of the role of biodiversity on their properties;
- communication activities aimed at building the capability of extension personnel to promote practices to maintain biodiversity and sustainability.

Time lines (start, finish dates, important milestones):
January 1998(?) to June, 2001

Funding sources:
MRC NAP3 program

Brief summary and findings to date (max. 250 words):
This project has only just begun

Summary of methods (max. 250 words):
The research project will be conducted in a whole property context so as to enable producers and other stakeholders to consider the trade-offs between production and conservation of biodiversity. The project will concentrate on increasing the underpinning knowledge of biodiversity as it relates to sustainable beef production and, as a consequence, bring about change at a property level.

This project was conceived and designed alongside the socio-economic project "Applying management principles on variegated landscapes: identifying production/conservation tradeoffs" (LWRRDC/EA Project CTC9). An additional project, "Responses of Vegetation to Land Use and Disturbance" in the Global Change and Terrestrial Ecosystems Program (GCTE Task 2.2.1) will provide a strong intellectual framework in which to analyse and interpret data from the experimental work, and to seek out relevant findings from related systems in other countries.

Research project proforma No. 17 - NAP3 scoping study

Title of project:

Management of native pastures oversown with stylo

Organisation(s) responsible (name, address, phone, fax, email):
QDPI

Project leader/contact (name, address, phone, fax, email):
Deryk Cooksley,
QDPI,
PO Box 1054,
MAREEBA, QLD 4880

Location of research:
Experimental site is at Dimbulah, Qld; monitoring sites on commercial properties are in the lower Peninsula region and upper Burdekin catchment.

Objectives (dotpoints):
By June 2001, identify and communicate practical methods of maintaining a balance of grass and legumes in oversown native pastures by:

- developing management systems (fire, grazing) for maintaining native perennial grasses in pastures oversown with *Stylosanthes* species;
- developing methods for introducing and managing exotic grasses into stylo-dominant pastures;
- assessing the economic benefits of the different management systems;
- communicating and promoting management practices that encourage stability and productivity of pastures oversown with stylos such that:
  - all agency staff, agribusiness personnel and livestock producers associated with stylo-based pastures are aware of these by the year 2000; and
  - 'best bet' management practices are adopted by stylo users by the year 2001.

Expected outcomes and implications for the grazing industry (dotpoints):

Time lines (start, finish dates, important milestones):
1998 to June 2001 (?)

Existing and new monitoring sites will be monitored in April-May 1998, May 2000 and May 2002.

Funding sources:
MRC NAP3

Brief summary and findings to date (max. 250 words):
Phase 1 of this project focused on: (1) establishment of a field experiment near Dimbulah to test the effects of grazing pressure, spelling, fire and sowing of exotic grass seed on the restoration of grass component, and (2) initial monitoring of commercial sites. Drought conditions delayed progress with both activities but the field site is now starting to produce important treatment differences. Phase 2 of the project (funded under NAP3) will focus on:

- interpretation and reporting of the field experiment;
- expansion of the monitoring activity to at least 20 commercial sites; and
- communication with the industry.

Summary of methods (max. 250 words):
The objectives of the project will be met through 4 major activities:

- manipulating the grass-stylo balance through grazing, spelling, fire and seeding - this is continuation of the field experiment commenced in the first phase; the experimental sites and treatments will be continued for the duration of phase 2;
- monitoring pasture dynamics of native pastures oversown with stylos and grasses on commercial properties - this is an expansion of a monitoring program that commenced in phase 1 with 10 sites in the lower Peninsula and 5 in the upper Burdekin; 5 to 10 new monitoring sites will be established mostly in the Burdekin catchment and measurements will be made of pasture yield, composition and species frequency;

- development of management systems for maintaining grass-stylo balance in oversown pastures (see details below) - this activity seeks to integrate results from the experimental work and monitoring with other relevant information on stylo management to build management systems for managing grass-stylo pastures on different land types.; and
- communication of management options to the industry.

Development of management systems for maintaining grass-stylo balance in oversown pastures
The potential rates of change in stylo content of pastures will vary between land types and climates. For each land type, the management system will consider:

- risk of slow stylo build-up (and therefore reduced return on investment);
- risk of transition from moderate stylo content to stylo dominance;
- responsiveness of stylo-grass balance to grazing management;
- responsiveness of stylo-grass balance to fire plus grazing management;
- likelihood of establishment and spread of exotic grasses.

A conceptual model of grass-stylo balance will be developed and used to illustrate the effectiveness of different management systems. A current working model assumes that stylos function ecologically like shrubs and that competition for water leads inexorably to stylo dominance. In developing the model, account will be taken of rainfall variability and the occurrence of episodic events on establishment and population dynamics.

The economic effects of different management systems will be assessed by investment analysis based on the costs of each system and on the estimated benefits of avoiding longer-term problems with continuity of forage supply, soil acidity and soil erosion.

Research project proforma No. 18 - NAP3 scoping study

Title of project:
Managing tropical woodlands to control exotic woody weeds

Organisation(s) responsible (name, address, phone, fax, email):
CSIRO Tropical Agriculture, PMB Aitkenvale, QLD 4814 and TWRC, PO Box 187, Charters Towers, QLD 4820

Project leader/contact (name, address, phone, fax, email):
Tony Grice, CSIRO Private Mail Bag, Aitkenvale, QLD 4814, Ph 07 47538540 Fax 07 47538600 Email: Tony.Grice@tag.csiro.au

Location of research:
Lansdown Research Station and Charters Towers District

Objectives (dotpoints):
By June 1999 to:
1. Quantify, for land management purposes (i.e. seasons, plant size), the amount of time that elapses between germination of a woody weed cohort and seed production by that cohort;
2. Determine biologically and economically efficient burning frequencies from the relationship between individual woody weed plant size and density and forage production;
3. Develop management practices (fuel loads, environmental conditions, season etc) for the frequency and intensity of burning to control a suite of exotic woody weeds by limiting seed production and direct mortality of juvenile and adult plants;
4. Develop a computer based decision support package for use by research and extension officers to assist property managers to evaluate ecological and economic priorities for prickly acacia control at the paddock scale;
6. Integrate ecological data (seed production, seedling establishment, growth rates, time to flowering, burning mortality etc) into economic analysis for decision support of rubbervine management at the paddock scale.

Expected outcomes and implications for the control of woody weeds (dotpoints):
1. Recommendations for ecologically-based management practices for the control of woody weeds using fire
2. Decision support tools for the management of prickly acacia at the paddock scale

Time lines (start, finish dates, important milestones):
Start date: July 1 1996, End date: June 30 1999.

Funding sources:
Meat Research Corporation, CSIRO, QDNR

Brief summary and findings to date (max. 250 words):
The initial phase of this project (NAP2 CS.219) was oriented towards developing management principles for maintaining landscapes in a weed free condition when exotic weeds were present in low populations. The results from that work have shown that weed invasion may not be as constrained by competition from herbaceous vegetation to the extent that most land managers, advisers and researchers believe and that fire, if properly managed, can be an effective tool for both containing the spread of weeds. In extending this work into the next phase, we wish to more fully address the long-term nature of the problem of using low input techniques to manage weed problems and develop explicit management practices that producers can confidently and reliably implement.

Summary of methods (max. 250 words):
All of the objectives can be accomplished on small (~ 1 ha) plots using tagged woody weed plants.

Objective 1: Seedling growth rates and reproduction will be determined by monitoring individual plants that were planted in 1991/92, 1993/94 and 1994/5 into a variety of grass cover types. The sites are located at Townsville (CSIRO), Giru (CSIRO), Lansdown (CSIRO), Charters Towers (TWRC), Hughenden (TWRC) and Julia Creek (CSIRO). Plant attributes (survival, height, basal diameter) will be measured twice yearly.

Objective 2: Fires will be conducted on all plots (Lansdown, Larkspur) in 96/97 and 97/98, thereafter, only half of each set of plots will be burnt each year. Burn intensity will be measured by thermocouples and/or flame front movement. Burning frequency will be either yearly or biennially. Impacts on plants will be determined by size class and species in quarterly measurements. Burn intensity and plant damage will be correlated with fire temperature and duration via plant community scale fire behaviour models.
Objective 3: Soil moisture and forage production (quality and quantity) will be determined around individual woody weed plants and in stands of different densities in populations at Lansdown. Soil moisture will be monitored on a bi weekly basis during the wet season and on a monthly basis during the dry season. This data will be integrated into paddock scale forage production models via the GRASP program.
Objective 4: Data from paddock scale prickly acacia increase studies will be used to develop paddock scale decision models describing biological and economic outcomes of treatments. The original data sets will be generated from chronosequential aerial photography analysis that describe acacia density in 60 x 60 m cells. Probabilities of shifts among density categories will be determined by the means of Markov chain calculations. Visual displays will allow the user to enter different combinations of acacia densities along riparian areas and in upland populations and simulate the effects of different climatic regimes through a series of 15 y time-steps. The output will be displayed as changes in colours within the different landscape components of the paddock. The output will also serve as a basis for the calculation of economic efficiencies for treating different paddocks. The economic analysis will be outside the decision support software.

Research project proforma No. 19 - NAP3 scoping study

Title of project:
Managing woodlands : Developing sustainable beef production systems in northern Australia.

Organisation(s) responsible (name, address, phone, fax, email):
CSIRO Tropical Agriculture, PMB Aitkenvale, QLD 4814 and QDPI, PO Box 876, Charters Towers, QLD 4820

Project leader/contact (name, address, phone, fax, email):
Andrew Ash, CSIRO Private Mail Bag, Aitkenvale, QLD 4814, Ph 07 47538540 Fax 07 47538600 Email: Andrew.Ash@tag.csiro.au

Location of research:
Around Charters Towers, all within the Burdekin catchment. Three sites specifically, Hillgrove/Eumara Springs; Cardigan; Allan Hills/Lakeview

Objectives (dotpoints):
By July 2001 to:
1. Develop management guidelines on the use of stocking rate, fire and strategic spelling to encourage deteriorated native pasture back to a more desirable state and to prevent decline of pastures presently in good condition.
2. Develop a predictive understanding of the effect of trees on pasture production to aid management decisions on the extent of tree clearing, the optimal frequency of regrowth control and the use of fire to manage woody species.
3. Link management recommendations from Objectives 1 and 2 into a range of extension activities, including property management planning modules, small group activities, landcare groups, training workshops.
4. Assess the economic benefits and costs of various grazing management strategies.
5.

Expected outcomes and implications for the grazing industry (dotpoints):
1. Improved sustainability of beef production enterprises in north-east Queensland through adoption of grazing management principles that maintain or improve pasture condition.
2.

Time lines (start, finish dates, important milestones):
Start date: July 1 1996, End date: June 30 2001.

Funding sources:
Meat Research Corporation, CSIRO, QDPI

Brief summary and findings to date (max. 250 words):
This project aims to (a) develop management guidelines (fire, grazing, strategic spelling) to manipulate native pasture composition, and (b) quantify soil water use by trees and grasses for improved prediction of forage production in topical woodland environments. Grazing studies and tree-grass interactions are being conducted on three commercial properties in Dalrymple Shire.

The results to date show that significant recovery of run-down pastures can be achieved with either light stocking without spelling or with heavier stocking and wet season spelling. However, while forage yields and botanical composition appear to have recovered at two of the three sites with either of these two grazing strategies, this recovery has been achieved through regeneration of existing plants with little recruitment of new plants.

Modelling studies using historical climate records indicate that in comparison with good condition pasture, deteriorated pasture has animal production that is more variable, there are more years where there is a predicted weight loss (therefore requiring additional supplementation), and soil loss is considerably higher.

Summary of methods (max. 250 words):
In the first phase of this MRC project (1992-1996) a number of field experiments and modelling studies were initiated to understand the management actions and environmental requirements necessary to manipulate vegetation in tropical tallgrass pastures and to maintain grass legume balance in pastures oversown with *Stylosanthes* species.

The second phase of this project is concentrating on native pastures with experimental work proceeding to (a) develop management guidelines for manipulating pasture composition and (b) quantify soil water use by trees and grasses for improved prediction of forage production. This work is being carried out on three soil types of contrasting fertilities in north-east Queensland: Hillgrove/Eumara Springs - euchrozem; Cardigan - neutral red duplex; Allan Hills/Lakeview - yellow earth. The work is being carried out using pastures which initially were in contrasting condition i.e. State I - good condition pasture dominated by desirable perennial grasses and State II - deteriorated pasture dominated by less palatable perennial grasses with annual grasses and forbs much more prevalent.

Additionally, in this phase strong emphasis is being placed on improved adoption of research through linking management recommendations into a range of extension activities (property management planning modules, group activities such as LCD groups and landcare groups) and by providing some economic evaluation of different management scenarios.

Research project proforma No.20 - NAP3 scoping study

Title of project:
Mechanisms of pasture change and strategies for restoring the productivity of spear grass and *Aristida/Bothriochloa* grasslands

Organisation(s) responsible (name, address, phone, fax, email):
Queensland Department of Primary Industries

Project leader/contact (name, address, phone, fax, email):
Col Paton,
Brian Pastures Research Station,
Queensland Department of Primary Industries,
PO Box 118,
GAYNAH, QLD 4625

Phone: (07) 4161 1602
Fax: (07) 4161 1954

Location of research:
Three sites in the Burnett River catchment: "Glencoe" south of Monto; "Derarby" south of Mundubbera; and "Corrunovan" west of Proston.

Objectives (dotpoints):
- By the year 2000, develop cost efficient whole property management principles that will enable individual landholders to transform wiregrass infested pastures into productive speargrass pastures.
- To demonstrate those management principles and encourage their adoption through a planned communication strategy.
- By the year 2000 have producers in the Burnett armed with the knowledge of these management principles and how to apply them as part of their whole property management.

Expected outcomes and implications for the grazing industry (dotpoints):
Methods to allow graziers to convert wiregrass infested pastures into productive speargrass pastures.

Time lines (start, finish dates, important milestones):
July 1996 - June 2000

Funding sources:
MRC (NAP3)

Brief summary and findings to date (max. 250 words):
This project is addressing the problem of wiregrass and other unpalatable pasture species dominating in commercial black speargrass pastures. Currently, three commercial sized demonstrations of pasture and cattle management principles for achieving speargrass dominance are using tow annual burning and strategic stock management options to compare with unburnt and commercially managed paddocks.

The demonstration is showing that annual burning and reduced stocking pressure can improve pasture composition, individual cattle weight gains and profitability.

A feature of the project is the close producer involvement. After learing about suitable pasture and cattle management principles, local producers are deciding on treatments for paddocks. Some producers are helping with pasture sampling.

Summary of methods (max. 250 words):

Research project proforma No. 21 - NAP3 scoping study

Title of project:
Rangeland monitoring, Victoria River District and Indicators for Sustainable Land Production and Condition

Organisation(s) responsible (name, address, phone, fax, email):
Department of Lands, Planning and Environment
GPO Box 30,
PALMERSTON, NT 0831

Project leader/contact (name, address, phone, fax, email):
Bob Karfs and Rod Applegate
(Address as above)

Location of monitoring sites:
Victoria River District, NT

Objectives (dotpoints):
- Integrate image analysis methods & ground-based methods.
- Understand rangeland dynamics within a state and transition framework.
- Develop appropriate methodology for reporting on land condition.

Expected outcomes and implications for the grazing industry (dotpoints):
- Objective information used to assess land management.
- Useful products combining property infrastructure, resource information and land condition trend into a suitable format.

Time lines (start, finish dates, monitoring frequency):
Start: 1995 —
Monitoring frequency: core sites — annual
regional sites — every 3 years

Funding sources:
CRC for Sustainable Savannas and NT government

Brief summary on progress to date (max. 250 words):
- Thirty-three core sites established on one property with ground data collected annually since 1995.
- An additional 30 sites established on surrounding properties.
- Total area covered approximately 70 000 km^2.
- Data analysis continuing.

Summary of monitoring methods, procedures (max. 250 words):
- Rangeland sites selected on stratified landtypes and in a range of states using a GIS and temporal satellite data.
- Ground assessment on 1 ha site includes quadrat cover and frequency estimates, complete species list. Environmental data are collected as per McDonald *et al.* (1990) (Australian soil and land survey field handbook) and surface condition assessment as per Tongway and Hindley (1996).
- Temporal satellite data used to extrapolate point source data.

Research project proforma No. 22- NAP3 scoping study

Title of project:
Reclamation of degraded land in the Desert Uplands

Organisation(s) responsible (name, address, phone, fax, email):
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Department of Environment,
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TOWNSVILLE MC, QLD 4810

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mal.lorimer@env.qld.gov.au

Project leader/contact (name, address, phone, fax, email):
Dr Mal Lorimer
(Contact details as above)

Location of research:
Desert Uplands biogeographic region

Objectives (dotpoints):
- Demonstrate that degraded land can be brought back to some level of productivity.
- Compare rates of restoration using 3 different grazing pressures and 2 cultivation treatments (nil and minimal).

Expected outcomes and implications for the grazing industry (dotpoints):
- the importance of preventing land degradation.
- the difficulty and time required to restore pastures.
- the lost productivity in having degraded land.
- the importance of managing/controlling grazing pressure.

Time lines (start, finish dates, important milestones):

Start: November 1996; **Finish:** November 1999
Milestones: results of sampling the 6 sites pre- and post wet season

Funding sources:
NHT and Dept of Environment

Brief summary and findings to date (max. 250 words):
- Each of the 6 sites representing six different land types have responded differently to the five treatments. The most severely degraded areas are slowest to respond.
- Some properties have severe feral grazing problems
- Cultivating scalded areas is a waste of time and money unless stock are completely removed.
- Initial revegetation may consist only of weeds and useless forage species but they are the vital first step in trapping more soil, seed, organic matter and water for other plant species to get established.

Summary of methods (max. 250 words):
Nil grazing — no cultivation
— cultivated: single rip lines 5 m apart.
Specially designed 2 m high fence to keep out rabbits, sheep, goats, cattle and kangaroos.

Restricted grazing — no cultivation
— cultivated: as above
5-strand barbwire fence keeps out cattle, sheep and goats but not ferals.

Control — no cultivation
— cultivated: as above
No fencing

Measurements

- botanical composition
- total pasture dry matter using the Kank-set method
- grass basal area using point frame
- litter cover using point frame

Photographs

- general view of each plot from reference point
- ground cover of each plot from reference point

Research project proforma No. 23 - NAP3 scoping study

Title of project:
Sustainability of *Stylosanthes* based pasture systems in nothern Australia: managing soil acidity

Organisation(s) responsible (name, address, phone, fax, email):
CSIRO Land and Water

Project leader/contact (name, address, phone, fax, email):
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AITKENVALE, QLD 4814

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Location of research:
Townsville, northern and central Queensland and NT

Objectives (dotpoints):
- Establish permanent monitoring sites throughout northern Australia to assess long-term soil fertility and moisture trends under *Stylosanthes* and native pasture systems.
- Develop a soil acidity risk assessment map for the Dalrymple Shire at a level that will assist resource managers in identifying areas most vulnerable to accelerated acidification. In addition, a simple field based soil tool-kit will be developed to assess soils for their sensitivity to accelerated soil acidification.
- Evaluate the impact of different *Stylosanthes* management strategies implemented at Springmount, Mareeba, on the rate of acidification. This will facilitate the development of management strategies to minimize *Stylosanthes* dominance in improved pastures.
- Conduct greenhouse and laboratory studies to ascertain the tolerance of grass and *Stylosanthes* species to acid soil infertility and assess the impact of ash produced after burning as an acid soil ameliorant.
- Quantify the mineral nitrogen dynamics under a *Stylosanthes* dominant pasture in order to assess the contribution of nitrate leaching to acidification. Using published data, attempt to establish a total nitrogen budget for pastures with and without *Stylosanthes*.
- Develop a comprehensive communication plan in conjunction with QDPI which will facilitate awareness among producers of the possible negative effects of *Stylosanthes* dominant pastures on the soil resource base and to suggest management strategies to minimise these negative impacts.

Expected outcomes and implications for the grazing industry (dotpoints):
- By quantifying the inherent fertility status of various pasture production systems at long-term monitoring sites, this project is expected to significantly improve our understanding of the long-term sustainability of legume based pasture systems in the semi-arid tropics.
- The outcomes of the project will assist in the development of a soil acidification risk assessment model which could potentially be used in delineating soil types that are prone to accelerated acidification and thereby provide knowledge a the farm planning level.
- In addition, the project will increase understanding on the long-term implications and mechanisms associated with accelerated acidification and the tolerance of various grass and *Stylosanthes* species to acid soil infertility which will assist in the development of strategies to reduce the risk of acidification.

Time lines (start, finish dates, important milestones):
July 1997 to July, 2201

Funding sources:
MRC NAP3 and CSIRO

Brief summary and findings to date (max. 250 words):

Summary of methods (max. 250 words):
The project has four sub-projects:

- Establishment of permanent monitoring sites for the assessment of soil fertility and water changes in northern Australia - various chemical properties will be determined for up to 32 sites with a range of pasture management; on 4 sites, differences in the soil moisture status between native and *Stylosanthes* dominant pastures will be determined.
- Predicting the risk of acidification - the proposed map of acidification risk will be based on rainfall, surface soil P status and pH buffer capacity. Rainfall and surface P will be compiled from current data sets from the Dalrymple Shire Resource Survey; transfer functions will be used to predict soil pH buffer capacity. The map will be validated through strategic sampling on properties with long-term *Stylosanthes* pastures.
- Development of sustainable legume based production systems - a series of studies will be undertaken to:
  - assess the impact of selected management systems on rates of soil acidification from a long-term grazing study established at Mareeba in 1982;
  - assess the long-term effect of soil acidification on chemical properties and the amelioration of acidity through litter and ash deposition in columns.
  - to determine the effect of various levels of soil acidity on the germination, establishment, growth and reproduction of a number of grass and legume species, using glasshouse trials;
  - quantify the mineral nitrogen dynamics under a Stylosanthes dominant pasture system in order to assess the contribution of nitrate leaching to acidification.
- Establishment of a project consultation group and development of a extension project with QDPI which will transfer information from the project to producers; this will include a workshop for QDPI extension staff to inform them of results to date and future research activities.

Research project proforma No. 24 - NAP3 scoping study

Title of project:
Woodland management and woody weed control for Queensland's beef pastures

Organisation(s) responsible (name, address, phone, fax, email):
Queensland Department of Primary Industries
Tropical Beef Centre
PO Box 5545
Rockhampton Mail Centre Q 4702

Phone: 07 49238100 Fax: 07 49238222

Project leader/contact (name, address, phone, fax, email):
Dr Bill Burrows, DPI TBC, PO Box 5545 Rockhampton Mail Centre 4702

Phone: 07 4923 8100 Fax: 07 4923 8222 email burrowb@dpi.qld.gov.au

Location of research:
Many sites throughout Queensland

Objectives (dotpoints):
- Increasing our understanding of the dynamics and ecology of eucalypt woodlands by monitoring change in both undeveloped and developed situations.
- Developing control techniques for specific emerging native woody weeds.
- Further development of the decision support packages "Woody weed advisor" and "Grassman" and testing the former's use and acceptance through survey.
- Finalising the 'TRAPS' (Transect Recording and Processing System) manual and supporting software and to promote its use as a long term woodland monitoring tool for R&D specialists in northern Australia.

Expected outcomes and implications for the grazing industry (dotpoints):

Time lines (start, finish dates, important milestones):

Funding sources:
Meat Research Corporation

Brief summary and findings to date (max. 250 words):

Summary of methods (max. 250 words):

Research project proforma No. 25 - NAP3 scoping study

Title of project:
How long will soil resources last with current grazing practices? - Research component.

Organisation(s) responsible (name, address, phone, fax, email):
Department of Natural Resources (Queensland)
Name Mr Mark Silburn
Address APSRU, Department of Natural Resources
PO Box 102, Toowoomba 4350
Ph (07) 46 881 281 Fax (07) 46 881 193

Project leader/contact (name, address, phone, fax, email):
as above

Location of research:
DNR South region - field work is being undertaken in Taroom/Wandoan, Chinchilla, Crows Nest and other area. Runoff and erosion "permanent" field sites are located North of Chinchilla and South on Ipswich.

Objectives (dotpoints):
1. Bring together data from past soil erosion studies in grazing lands.
2. Establish field monitoring experiments with interested grazier, extension and Landcare groups.
3. Develop and apply methods to calculate sustainability of soil resources in grazing systems.
4. Work with grazier groups to package the information for use in extension activities (eg, PMP, Droughtplan, Safe Carrying Capacity).

Expected outcomes and implications for the grazing industry (dotpoints):
The project will integrate a wide range of existing research on land and pasture degradation and apply this knowledge to grazing properties, thus providing a mechanism to combine research and producer experience. Some specific outcomes will be:-
- Tools for assessing grazing pressures and practices so as not to degrade the soil resource.
- An assessment of sustainability for existing and alternative practices, for case study properties.
- Comparison of various land types, i.e., sensitive or insensitive to losses of soil and nutrients.
- Appraisal of graziers views on robustness of land types and comparisons with measured results.
- Definition of the long term costs of short periods of over grazing, for various land types.
- Develop grazier and extension staff skills in selecting grazing practices that are sustainable.

Increased effectiveness of Property Management Planning, Droughtplan and Safe Carrying Capacity programs by providing quantitative measures of sustainability

Background (problem).
There are concerns that some grazing systems are under serious threat of declining production due to soil erosion, decline in soil structure and loss of soil fertility. Others are probably sustainable but may be 'tarred with the same brush'. There is very limited scientific data on which to base judgements. However, it is known that when cover is reduced, a large proportion of rainfall is lost as runoff, reducing capture of rainfall for pasture growth and often eroding nutrient rich surface soil. Even a short period of low cover, such as a drought, may reduce long term production - a site monitored in SE Qld lost 10 % of total N & P in the surface soil during the last two (very dry) years. As grass production decreases, grazing pressure is increased, cover continues to decline and if the cycle continues the system may be in danger of collapsing. Some sites have already collapsed, others may be about to and some never will - how can graziers find out if their land is in this cycle and if it is, what to do to break the downward spiralling cycle?

What is missing at present is a sound basis for graziers to determine what their land and production system can support and what is the nature of the current trend and future trends under various management options. By integrating research results, grazier knowledge and historic rainfall records, the project will allow us to estimate the relationship between grazing pressure, soil and nutrient losses, production and soil condition. It will focus on the condition of the soil resource and how it is likely to change.

Time lines (start, finish dates, important milestones):
PROJECT FUNDING DURATION (36 mths max)
Expected Start date 1/97
Expected Completion date 6/2000

Funding sources:

1) National Heritage Trust (National Landcare Program)
2) Queensland Department of Natural Resources
3) Landcare Groups in Taroom, Chinchilla, Crows Nest Shires (& others later in the project)

Brief summary and findings to date (max. 250 words):
This project addresses the major issue of sustainability of soil resources in grazing lands. By working with grazier and Landcare groups and conducting field monitoring experiments it will combine grazier knowledge and research results to provide a better basis for determining grazing pressures that will not degrade the soil. At present there is little reliable information available on important questions such as which land types are most at risk and how grazing management affects sustainability. In this project, data from past monitoring of erosion in grazing lands and data from current research, will be collated and presented in readily accessible forms. Sustainability will be assessed using measured site data (eg soil, pasture, nutrient data) and well-established methods for calculating forecasts of pasture production, erosion and nutrient losses. Sustainability will be defined on the basis of whether pasture production declines in the longterm or not. The project will contribute to existing extension activities (PMP, Droughtplan, Safe Carrying Capacity, etc.).

To date we have initiated studies in collaboration with landcare groups on:-

- effect and longevity of ripping/cultivating pasture soils, on surface roughness, infiltration and pasture production.
- runoff, erosion and nutrient losses (plot study) from a red duplex soil in a "light forest" land resource unit, with and without timber clearing.
- effects of tree clearing/retention on infiltration and soil properties
- effects of grazing system (eg. time controlled/cell grazing) on infiltration and soil properties.

Also, we have :-

- measured the interrill erodibility and effects of cover on erosion and infiltration capacity, for five contrasting soils in the southern speargrass zone of Queensland (as a contribution to assessing the capability of these land resource units). Similar studies as under way for two soils in the Taroom/Wandoan area.
- runoff, erosion, nutrient loss, soil water and pasture data has been (partially) collated for the QDNR "Springvale" and "Mt. Mort" sites. For Springvale, these data have been used to derive water balance parameter for pasture modelling.
- supported a undergraduate student project through University of Queensland, studying the above-ground and root biomass dynamics for a range of pasture treatments. This is needed to allow linkage of pasture growth models with soil carbon/nitrogen models so that they can be used for modelling longterm sustainability of pastures.

Summary of methods (max. 250 words):
In the Condamine/Maranoa/Balonne, there are no past or current studies of erosion and nutrient losses from native pastures to provide basic data. Thus a monitoring site will be established in this project. It will be part of the project to find an interested group of graziers/landcarers, a land system considered at risk, work out an achievable set of measurement techniques (based on our experience in erosion research and the interests of the group) to compare adjacent paddocks (fence line differences), exclosures, 'artificial heavy grazing' etc.
Other activities include:-

- visit Landcare and Grazier etc. groups throughout the region who express interest in issues such as management of grazing land, sustainability etc. and visit existing trial sites.
- negotiate a workable set of field monitoring activities with enthusiastic groups ie where the project team can add monitoring elements to existing activities or establish new activities. These may include short term (eg. 1 day rainfall simulator action learning workshops), occasional (eg. annual Grass-check type measurements) or longterm (eg. measure runoff, erosion etc) activities, as deemed appropriate by the group involved. Longer term measurements of runoff, soil and nutrient loss from several grazing treatments will be required at at-least one site (core site) so that sustainability can be evaluated.
- record experiences regarding what information graziers find most useful and what forms of presentation they appreciate most.
- collation of information from past soil erosion studies in grazing lands.
- use these data and pasture/water balance/erosion simulation models to assess the longterm sustainability of pasture production .

Research project proforma No. 26 - NAP3 scoping study

Title of project:
Impact of downstream effects of agricultural practices in the Fitzroy Catchment

Organisation(s) responsible (name, address, phone, fax, email):
Queensland Department of Natural Resources
Collaborators include: Queensland Department of Primary Industry and Central Queensland University

Project leader/contact (name, address, phone, fax, email):
Robert Noble
Senior Chemist
Department of Natural Resources
Phone: 07 4992 9114
Locked Mail Bag 1
Biloela Research Station,
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Fax: 07 4992 3468

Location of research:
Fitzroy Catchment, Qld

Objectives (dotpoints):
To assess the "state of health" of major streams in the Fitzroy River Catchment. Eleven monitoring sites were established to represent the major sub-basins the Fitzroy system:

- Lower Comet River
- Upper and lower Dawson river
- Nogoa River upstream of Fairbairn Dam
- Isaac River

Expected outcomes and implications for the grazing industry (dotpoints):
Time lines (start, finish dates, important milestones):
June 1993 to June 1998

Funding sources:
NHT, QDNR, QDPI and Central Queensland University

Brief summary and findings to date (max. 250 words):

- The current project has determined important baseline information on water quality and "stream health" in the Fitzroy catchment system during the period 1993-96. Moderate flows in the Dawson and Comet sub-catchments have been found to carry quite high sediment and nutrient loads over the period of the project. Suspended sediment, nitrogen and phosphorus concentrations are higher than environmental guidelines at downstream locations particularly during higher stream flows.
- The biological monitoring data have shown a generally "healthy" biological state for most sites but have highlighted several major issues including dominance by blue-green algae at some locations.
- A final monitoring after the summer of 1995/96 has been carried out and this extends the validity of the data on water quality and stream health.
- Presently the information is being packaged and made available to all stakeholders by oral presentations to Landcare groups and at conferences, by papers and posters at conferences, by publications as news and magazine articles and report preparation. Transfer of information and interaction with stakeholders is continuing.
- A 100 page summary report with results from the project has been written and use of the already allocated project funds for publication of the report will allow maximum benefit to stakeholders from the work. The report will be available for use in conjunction with the "Fitzroy CatchmentTrailer" in the continuing Landcare project "Water Quality in the Fitzroy Catchment - Community Ownership".

Summary of methods (max. 250 words):

- The eleven sites were sampled three times under base-flow conditions for a range of physico-chemical, chemical and biological parameters.
- Four sites on the Dawson River were sampled every two months from August 1994 for physico-chemical, chemical and biological parameters.
- Any flows during 1994/1995 in the major sub-basins were sampled.

Strict sampling protocols and post-sampling preservation techniques were used to ensure representative sampling and sample integrity. Physico-chemical parameters were measured *in-situ*.

Research project proforma No. 27 - NAP3 scoping study

Title of project:
Management strategies for the control of cyanobacterial blooms in the Fitzroy River barrage.

Organisation(s) responsible (name, address, phone, fax, email):
CSIRO Land and Water
Central Queensland University
Queensland Department of Natural Resources
Rockhampton City Council

Project leader/contact (name, address, phone, fax, email):
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Location of research:
Fitzroy River (Rockhampton, Queensland)

Objectives (dotpoints):
1. To establish the role of flow, stratification, turbidity and nutrient dynamics in the development and persistence of cyanobacterial blooms in the Fitzroy River Barrage (FRB) by a combination of field measurements and modelling.
2. To extend an existing predictive model of stratification and algal growth dynamics in rivers by incorporating nutrient dynamics, and to adapt and verify the updated model for the FRB.
3. To use the model to investigate and select the most favourable strategies for cyanobacterial control in the FRB.
4. To assess the potential of the general applicability of the model to other temperate and tropical rivers affected by cyanobacterial problems throughout Australia.

Expected outcomes and implications for the grazing industry (dotpoints):
- Due to an improved understanding of the conditions conducive to the development and persistence of cyanobacterial blooms, we will be able to assess the probability of occurrence and develop strategies to avoid blooms or reduce their severity.
- The inclusion of the role of nutrients and their sources will also assist in the problem of high sedimentation loads.
- The acquisition of a methodology for using flow to mediate blue-green algal concentration in Australian rivers.
- A reduction in water treatment costs and a more pleasant riverine environment.
-

Time lines (start, finish dates, important milestones):
Start: November 1996 Finish: June 1999
June 1998 Testing of model against first year of field data

Funding sources:
LWRRDC/MDBC
Queensland Department of Natural Resources
Rockhampton City Council

Brief summary and findings to date (max. 250 words):
Summary:
By a combination of intensive field measurements and modelling, we will establish the role of flow, stratification, turbidity and nutrient dynamics in the development and persistence of cyanobacterial blooms in the Fitzroy River Barrage (FRB). We propose to extend our existing predictive model of mixing dynamics and light limited algal growth dynamics in rivers to include nutrient dynamics. The model will be used to investigate and identify optimum flow management strategies for minimisation of cyanobacterial growth in the FRB and in other temperate and tropical rivers throughout Australia.

Findings to date:

- Persistent stratification occurred in the bottom 40 km of the river above the barrage from late August onwards. The extent of stratification is strongly dependent on wind speed which is highly variable.
- High algal numbers occurred at the upstream site earlier than downstream due to clearer waters and more stability of the water column. The onset of algal blooms at both sites was a result of more favourable ratio of light penetration depth to surface mixed layer depth.
- A bloom of *Anabaena circinalis* was observed at the upstream site in early September and its collapse coincided with non detectable phosphate concentration in the surface waters. Grazers were also seen in the algal samples before the collapse.
- A significant bloom of *Cylindrospermopsis* occurred from mid December to early February near the downstream site and was treated at the Water Treatment Plant with activated carbon. The toxicity was monitored weekly by the Council.
- Under low flow conditions, the stratification of the water column has a major influence on the nutrient distribution through little vertical mixing between surface and bottom layers, and through massive nutrient releases from sediments under anoxic bottom waters.

Summary of methods (max. 250 words):

Field measurements

We propose to make measurements over two years using continuously recording instrumentation of water temperature, together with on-site meteorological measurements to fully characterise the physical environment. Depth-integrated water samples will be collected weekly from July to December near the raft and near the upstream end of the weir pool, and analysed for cell counts and chlorophyll a. At each site samples at 1m and 7m depth will be analysed for nutrient levels (TP,TN, PO4, NH4, NOx) and conductivity. Vertical profiles of DO, pH, conductivity, turbidity, temperature and chlorophyll fluorescence will also be measured. Three intensive field trips a year will be undertaken. Peepers will be set at several locations in the sediments to examine the nutrients fluxes under oxic and anoxic conditions.

Model extension and verification

So far we have developed a model which successfully reproduces the stratification behaviour of a river section under a wide range of river discharge and meteorological forcing in the and lower Murray rivers. An algal growth function dependent on light availability has been incorporated. We propose to extend our model of mixing and light-limited growth dynamics to include the role of nutrients. The appropriate sources and sinks of nutrients within the water column as well as to and from the sediment/water interface will be modelled.

Management strategies

Our model will provide a tool for determining potentially optimal strategies based on the physical manipulation of the weir pool within the constraint of minimum flow disruption.

We propose to design strategies which will destroy the stratification as well as take advantage of it.

Research project proforma No. 28 - NAP3 scoping study

Title of project:
Marine biogeochemistry and sedimentation history

Organisation(s) responsible (name, address, phone, fax, email):
Australian Institute of Marine Science

Project leader/contact (name, address, phone, fax, email):
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Location of research:
GBR Lagoon near the mouth of the Herbert River, Queensland

Objectives (dotpoints):
To determine the history of sediment accumulation on the continental shelf in the vicinity of the Herbert River mouth, delta, estuary, GBR Lagoon, and slope, using radiochemical and contaminant tracers of recent sediment inputs

Expected outcomes and implications for the grazing industry (dotpoints):

Time lines (start, finish dates, important milestones):

Funding sources:

Brief summary and findings to date (max. 250 words):
Many conference proceedings and presentations, no journal publications yet.

- 500 grab sample reference collection for this portion of the GBR Shelf
- 30 Kasten cores of mainly riverine sediments in Hinchinbrook Channel mangrove mudbanks, Missionary Bay, Rockingham Bay, and the shelf out to 1000 m water depth.
- Geochemical contour maps of chemical elements across the shelf
- Rough models relating catchment land-use change to sediment core chemical changes.
- Beginning stages of mass balance models for organic and carbonate carbon in the Herbert Estuary and shelf region.

Summary of methods (max. 250 words):

- Sediment, carbon, nitrogen, and phosphorus mass balances for the terrestrial and marine inputs to the shelf.
- Contaminant (Cd, Hg, As, U, Tl, pesticides) mass balances for the Herbert River catchment, estuary, and shelf, in relation to the known 50-100 year history of land-use change.
- Calibration of methods and tools (e.g., natural and man-made isotopic tracers, geochemical determinations) for sedimentary history work in this region.
- Geochemical research on coral core history from fringing reefs of this region.
- Interaction with other projects to create synthetic models of catchment and continental shelf interactions.
-

Research project proforma No. 29 - NAP3 scoping study

Title of project:
Nitrogen deficiencies in Clay soils

Organisation(s) responsible (name, address, phone, fax, email):
CSIRO Wildlife and Ecology
Dept lands, Planning & Environment, NT

Project leader/contact (name, address, phone, fax, email):
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Location of research:
Victoria River district, NT

Objectives (dotpoints):
- To determine the extent to which the availability of nitrogen in clay soils limits the soil habitat value for perennial grasses in the northern savannas.
- To use these data, and associated data on soil surface condition (an Indicator set), to provide a procedure and an indicator to monitor any decline of nitrogen fertility by stress or disturbance and so develop early warning signs of non-sustainable use.

Expected outcomes and implications for the grazing industry (dotpoints):
- A clearer appreciation of the role of declining nitrogen availability in the sustainability of perennial grass pastures
- An assessment tool by which to monitor the effects of seasonal conditions and management on clay soil fertility

Time lines (start, finish dates, important milestones):
September 1997. Soils sampled in the field by DPENT and sent to Canberra for lab. Analysis.
October 1997 to May 1998. Lab analysis of pool size of mineraliseable N in soil samples.
May to July 1998. Interpretation of data.
July/August 1998. Field work to look at soil surface indicators with respect to loss of perennial grasses and the Nitrogen analytical data. Modification of existing indicator system and synthesis of new indicators, if appropriate.
September 1998 to December 1998. Preparation of papers and other communication means (for example field manuals) for field use by land managers and State agency staff.

Funding sources:
CRC for Tropical Savannas and internal CSIRO sources

Brief summary and findings to date (max. 250 words):
The change from perennial grasses to annual grasses in the VRD has been associated with a decline in soil surface indicators of nutrient cycling. This experiment will investigate whether the indicators are truly indicative on clay soils, which initially have good physical properties (gilgais and self-mulching surfaces). Lack of a seed-pool was rejected as there are huge differences across fencelines. No data are yet available on soil N status.

Summary of methods (max. 250 words):
We are using a landscape stratification process called Landscape Function Analysis to identify resource-rich and resource-poor zones, which indicate the basic functioning of ecosystems. The role of perennial grasses in the provision of ecosystem services can be compared with annual grasses. Our soil sampling recognises these zones and is stratified accordingly. Mineraliseable N is assessed by a procedure which measures both mineral n (nitrate and ammonia) and mineral plus mineraliseable N. Mineraliseable N s released by boiling water extraction, and is conceptually that pool of N which may be mineralised during a growing season, and represents the potential of the soil to supply N to plants when rain falls.

Research project proforma No. 30 - NAP3 scoping study

Title of project:
Nutrient and sediment inputs to GBR from north coastal Queensland.

Organisation(s) responsible (name, address, phone, fax, email):
AIMS

Project leader/contact (name, address, phone, fax, email):
Dr Alan Mitchell/Dr Miles Furnas
Biological Oceanography
AIMS, Townsville

Location of research:
Cape York to the Fitzroy R.

Objectives (dotpoints):
- Quantify amounts of nutrients and sediments to GBR
- Ecological impacts of above.

Expected outcomes and implications for the grazing industry (dotpoints):
- Not specifically related

Time lines (start, finish dates, important milestones):
Has been running several years, and should keep going.

Funding sources:
CRC Reef Research.

Brief summary and findings to date (max. 250 words):
River discharges to the shelf waters of the Great Barrier Reef (GBR) are variable on inter-annual, seasonal and event-related time scales. Most flow occurs during the summer wet season (November-April) and largely in response to discrete rainfall events within individual catchments. The largest flows are associated with cyclones and associated monsoonal rain depressions. Concentrations of dissolved nutrient species exhibit a complex range of behaviours with respect to seasonal flow dynamics. In contrast, particulate nutrient species and suspended solids concentrations are closely and positively related to discharge rates.

Brief summary and findings to date (continued)
Based upon flow-weight mean annual concentrations of N and P measured in the South Johnstone River (1990-91), annual river N and P inputs to the GBR were estimated to be 15.4 and 1.5 x 10^3 metric tons, respectively. Using mean monthly flow rates and estimated mean monthly nutrient concentrations in the twelve largest rivers entering the GBR, a second estimate of annual river N and P inputs of 21.1 and 2.0 x 10^3 metric tons was calculated. Both estimates based upon water sampling carried out to date are likely under-estimates as major floods in the two largest rivers (Burdekin, Fitzroy) have not been sampled and the resulting concentration-flow relationships included in the calculations.
Estimates of total nutrient inputs to the GBR shelf based upon total sediment inputs from rivers ranged from 54 to 98 x 10^3 metric tons for N and 11 to 30 x 10^3 metric tons for P. These estimates include geologically time-averaged sediment inputs from the Burdekin and Fitzroy Rivers, but ratios of nutrient input per ton of sediment are not weighted for composition differences between catchment types. Sediment discharges from individual watersheds are only indirectly estimated from studies in a few rivers and coastal sediment inventories.
At present, therefore, river nutrient inputs to the GBR can only be constrained at the order of magnitude level (10^4-10^5 metric tons per year for N, 10^3-10^4 metric tons per year for P). Further improvements await more intense sampling of sediment and nutrient discharge dynamics during flood events, particularly in the two largest dry-catchment rivers (Burdekin, Fitzroy) and the development of robust flow-discharge models allowing results obtained in intensively sampled catchments to be reliably extrapolated to more remote catchments.

Summary of methods (max. 250 words):
- flow related sampling mostly during the wet season.
- in situ turbidity monitoring (Fitzroy, Burdekin, Herbert, Tully, Normanby R).
- routine sediment and nutrient analysis.

Research project proforma No. 31 - NAP3 scoping study

Title of project:
Riparian zone management - central upper Burdekin catchment.

Organisation(s) responsible (name, address, phone, fax, email):
Dalrymple Shire Council
JCU Tropical Freshwater Centre

Project leader/contact (name, address, phone, fax, email):
Damian Burrows

Location of research:
Burdekin R. Catchment (Charters Towers).

Objectives (dotpoints):
Response of stream water quality and ecology to stream bank fencing.

Expected outcomes and implications for the grazing industry (dotpoints):
Implications for cattle access to streams
More sustainable resource base

Time lines (start, finish dates, important milestones):
1998-2001

Funding sources:
NHT

Brief summary and findings to date (max. 250 words):
Not started yet.

Summary of methods (max. 250 words):
- stream fencing
- comparison of fenced and unfenced areas (water quality and ecology).

Research project proforma No.32 - NAP3 scoping study

Title of project:
Stream Processes and Water Quality at Townsville Field Training Area.

Organisation(s) responsible (name, address, phone, fax, email):
JCU Tropical Freshwater Research
CSIRO Land & Water

Project leader/contact (name, address, phone, fax, email):
Richard Pearson

Location of research:
Townsville Field Training Area

Objectives (dotpoints):
Investigating impacts of cattle and army impacts on water quality and stream ecology.

Expected outcomes and implications for the grazing industry (dotpoints):
Looking at trampling, sediment disruption, and impacts on native fauna, particularly during the dry season (as sites that attract cattle AND natural biota).

Time lines (start, finish dates, important milestones):
1995-2001

Funding sources:
Army/LWRRDC

Brief summary and findings to date (max. 250 words):
Will fax or email abstract.

Summary of methods (max. 250 words):
- standard water quality sampling (seasonal/diurnal)
- examining ecological processes, eg, detrital breakdown, community dynamics.

Research project proforma No. 33 - NAP3 scoping study

Title of project:
Australian Grassland and Rangeland Assessment by Spatial Assessment
(Aussie GRASS)

Organisation(s) responsible (name, address, phone, fax, email):
Lead Agency: Qld Department of Natural Resources
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Third parties: QDPI, NT DPI&F, Ag WA, Primary Industries SA, Dept Env. And Natural Resources SA, NSW Ag, Dept Land and Water Conservation.

Project leader/contact (name, address, phone, fax, email):
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Location of research:
Research is being conducted throughout the rangelands of Qld, NT, SA, WA and NSW. The majority of computing work is carried out at Indooroopilly.

Objectives (dotpoints):

(1) Further technical development and eventual operationalisation of "Aussie GRASS", a national grassland and rangeland assessment model (whose prototype was developed in LWRRDC QPI20) that can explore and calculate:

- pasture and shrubland growth using the best mix of State and CSIRO models;
- climatic and drought analyses;
- the historical context of various biophysical values, including pasture biomass;
- the question of herbivore carrying capacity, and land sustainability; and
- the quantitative risks of land degradation in the context of local State environments, animal numbers and seasonal climatic forecasts.

(2) Facilitating a nationally co-ordinated effort of spatial grazing modelling, that:

- is developed in partnership with collaborators, stakeholders and clients,
- builds national teamwork, national co-operation, sharing of model technology and validation methods;
- creates research synergies;
- transfers technology to local State units; and

yet allows collaborators to self-actualise with local modelling efforts and research emphasis.

(3) Development of a nationally integrated extension program that:

- targets at and markets to land management clients at a district scale;
- delivers climatic risk and grazing management products to landholders, local drought and catchment committees, land care groups, land managers, and executive government;
- is delivered by local agencies in each State, yet sharing common national extension lessons and technical distribution systems; and
- is developed by participative group processes that produce a process of iterative development and feedback.

(4) Development, calibration and validation of the best pasture models for different ecoclimatic zones such as: the winter perennial/ shrubland zone across the south of the continent (WA, SA , western NSW), and the high rainfall temperate pasture systems of eastern NSW.

(5) Further calibration and validation of the GRASP pasture model in the NT and Kimberley, as well as integrating the extent of savanna burning in the NT and WA. Burning is increasingly becoming monitored by complementary remote sensing programs (e.g. the NT Bushfire Council).

(6) Facilitate the development of a national distribution system that provides at a continental scale, both a standardised archive of historical NOAA imagery; and a standardised regular feed of newly acquired imagery, that have been processed, navigated, radiometrically corrected and mosaiced to an agreed national standard.

(7) Explore how to interface :

- new seasonal climate forecasting systems such as produced by the Bureau of Meteorology Research Centre's (BMRC's) new sea surface temperature (SST) principal component analysis (this system unlike the Southern Oscillation Index (SOI) has considerable skill in southern Australia); and
- also potentially within the project's lifetime, forecasts from general circulation models (GCMs) of the atmosphere produced by the US Scripps Institution of Oceanography, USA, and the CSIRO Division of Atmospheric Research (DAR).

(8) Explore ways to develop synergies with other relevant research projects and also how to supplement the funding base for such a large national project. For example:

- the next LWRRDC general funding round will be approached for further research funding on rainfall interpolation and rainfall mapping by GMS-5 satellite imagery;
- GRDC will be approached to partially fund the interfacing of the new Bureau of Meteorology forecasting system based on sea surface temperatures; and
- in the final year of this proposal, the States and NT will make their own assessments about the long-term nature of the project and start to increasingly self-fund the operation, including core maintenance overheads.

Expected outcomes and implications for the grazing industry (dotpoints):
Occasional widespread droughts have severe short and long-term impacts on the basis for economic, ecological and socially sustainable agriculture and pastoralism in Australia. The interaction of pastoralism and climate variability has led to episodes of land and pasture degradation e.g. Burdekin catchment 1980-1996, south-west Queensland mulga 1960-1996; south-east Queensland (Burnett) 1876-1885, Western NSW, 1890-1903; Gascoyne WA, 1930s; South Australia, 1930-1940. Tothill and Gillies (1992) report that 42% of northern Australia's native grasslands exhibit some form of deterioration, while 18% are degraded. Since 1990 drought policies have focussed on the need to quantify the status of grasslands and rangelands from meteorological, biophysical, ecological, and economic perspectives to qualify for assistance. Local groups themselves (e.g. SW Queensland sheep producers and NT pastoral companies) are seeking assessments of what is a sustainable carrying capacity in the context of annual and decadal climate variability. State of the Environment reporting systems and the coming national Land and Water Audit will require quantitative assessments of the state of the our natural resource base.

The questions are:

- what is a safe level of pasture utilisation by grazing animals;
- what is the current assessment of the "season" relative to the 120 years of rainfall history, but from a biological not a meteorological perspective i.e. how much grass;
- what is the stocking rate (including macropods and ferals) in a district relative to what is "safe" ;
- what is the soil loss rate and ground cover in a district relative to what is "safe";
- what is the pressure on botanical composition, viz, pasture utilisation, relative to what is "safe";
- what is the state of the national grazing system that minimises greenhouse gas emissions and maximises
- biological sinks;
- how does grazing intensity and fire management, and property size relate to issues of biodiversity conservation;
- what are the effects that might be anticipated from climate change and what adaptation strategies are required;
- what are economically and ecologically sustainable property sizes across the nation given the background variation in climate and possible climate change;
- can we develop a cohesive national spatial assessment of the interactions of economic and ecological factors, despite State variations, geographic separation, and differences in industries, natural environments and research groups;
- can we use seasonal forecasts to improve our reactivity to climate variation by issuing land condition alerts and feed availability alerts on a regional basis, and, in good seasons issue "opportunity alerts" such as for fire management or market opportunities;
- can a holistic systems approach, which integrates "big" climate science with well calibrated and validated (from thousands of field measurements), proven computer models of grass growth and degradation processes, deliver a monitoring system which contributes to long-term economic and ecological sustainability of the

Australian pastoral industry; and
- can we deliver this information on the ground to graziers in paddocks through the continuum of time and scales up to national policy developers and administrators.

Products from this research will include simulated maps of:

- pasture growth relative to the history of all seasons;
- total standing pasture biomass relative to all seasons;
- stocking rate relative to "safe";
- pasture utilisation; and
- ground cover change.

The extension program will integrate these products with :

- existing climatological forecast systems available from the Bureau of Meteorology's seasonal outlook, QDNR's "Long Paddock" web site, and the new developing joint QDNR/BoM integrated meteorological web site - "SILO";
- sustainability research at QDNR and elsewhere which is gearing up to issues on soil loss, greenhouse emissions, climate change and property size;
- remote sensing research programs measuring tree cover, fire extent, and land cover change; and
- existing Property Management Planning activities and new PMP modules.

- The information products will be participatively developed with input from graziers, local drought and catchment committees, Landcare groups, and land management/policy administrators in State and Commonwealth governments.

- The products deployed will lead to assessment of seasonal condition, seasonal prospects for overgrazing or opportunities such as burning, land degradation and stocking rate adjustment. The same information set will be available from individual landholders, through regional groups to executive government. This will lead to a grazing industry better in tune with the changing seasons, changing decades, the grass resource and its sustainability. The products will form a basis of debate within regional drought committees and Landcare groups. Proactive management decisions will minimise land degradation through regional overgrazing and protracted drought events. The grazing industry will have tools to increase their level of self-reliance. The system will lead to more transparent and nationally consistent Drought Policy. Catchment health will be improved and downstream effects managed.

Time lines (start, finish dates, important milestones):
Start : 1/4/97
Finish: 31/12/99

Date for completion	**Description of milestone**
August 1997	Review and fine-tuning of sub-project research plans completed after further client consultation; staff appointed; sub-projects commenced; and steering committee has met.
September 1998	Development of new simulation models, enhanced data layers, some model validation and re-parameterisation, and trialling of new extension products.
September 1999	Regular operation of "Aussie GRASS" individually by State and NT collaborators; well defined products with a growing support base across Australia.
December 1999	QDNR and LWRRDC convene the "Aussie GRASS" Operationalisation Workshop in Brisbane.

Funding sources:
NCVP

Brief summary and findings to date (max. 250 words):
The Aussie GRASS spatial model is operational for Australia on a monthly timestep. Outputs/products are available to the researchers on a password protected website. These products are at this time prototype only.

Initial comparisons of some of the regional models has begun.

Summary of methods (max. 250 words):
There are eight main sub-projects within the Aussie GRASS work:

- Core development and co-ordination: Ensure superior technical co-ordination and technology transfer
- Extension sub-project: Develop a nationally co-ordinated but locally delivered extension program

- Southern Pastures sub-project: Develop and validate pasture models for southern Australia
- High Rainfall Zone Temperate pastures sub-project: Investigate pasture models for eastern NSW
- NT & Kimberley Rangeland sub-project: Develop GRASP for NT and WA, and include fire effects.
- NOAA data sub-project: Progress a national NOAA data processing standard and delivery system.
- State and NT funded activities to enhance point and spatial data sets.
- Development of all States and NT access to QDNR computing systems.

The three key principles to the overall modelling methodology are:

identification and inclusion of the best spatial and temporal data sets in the modelling framework;
comparison of regional models for their accuracy against the GRASP model, selection of the most applicable and inclusion within the spatial modelling framework; and
collection of field data ('spider mapping') throughout the rangelands for the purposes of calibration and validation of the model.

Further information on methodologies for individual sub-projects can be supplied if required.

Research project proforma No.34 - NAP3 scoping study

Title of project:
Central Highlands Regional Resource Use Planning Project

Organisation(s) responsible (name, address, phone, fax, email):
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Regional Resource Use Planner
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Ph. 07 3214 2327; Fx. 07 32142328
Mble. 04 1776 1467
Email allan.dale@tag.csiro.au

Project leader/contact (name, address, phone, fax, email):
as above

Location of research:
The project is undertaking a regional case study based on the Shires of Bauhinia, Emerald, Peak Downs, Belyando and Jericho in Central Queensland. The principal towns include Springsure (24°07'S; 148°05'E), Emerald (23°31'S; 148°10'E), Capella (23°05'S; 148°00'E), Clermont (23°50'S; 147°38'E), and Alpha (23°39'S; 146°38'E)

Objectives (dotpoints):
Through a pilot study based in the Central Highlands region of Queensland in collaboration with regional stakeholder groups:

1. Define the stakeholder groups, participants, principles and practices underpinning current regional resource use planning.
2. Identify how additional information and information technology, improved planning processes and greater involvement of the regional community could help to achieve the sustainable use and management of the region's natural resources.
3. Facilitate and provide additional information for the development of a widely available regional information base, and evaluate tools and methods, to assist the regional stakeholder groups to assess regional resource use options, including their social, economic, and ecological implications. Facilitate negotiation among these regional stakeholder groups and integration of their planning efforts.
4. Assist regional stakeholder groups to evaluate and reform the effectiveness of existing institutional arrangements, divisions of responsibility and broad policy frameworks in supporting the development and implementation of sustainable resource use and management within the region.
5. Facilitate coordinated regional stakeholder development of negotiated strategic options for improved resource use, including the identification of time frames and the individuals or groups responsible for implementing those options.
6. Evaluate the effectiveness of the project approach to resource use planning, and document methodological principles, processes, and techniques for supporting a regionally-driven, integrated and negotiated approach to resource use planning that can be applied to other rangeland regions in Australia. Publicise project results.

Expected outcomes and implications for the grazing industry (dotpoints):
- Structure and process for the Central Highlands grazing industry to develop industry-based strategies for sustainable resource use;
- Regional sustainability projects for the grazing industry which are negotiated with other significant stakeholders;
- Decision support tools and information systems to assist the grazing industry to assess resource use options at the regional scale

Time lines (start, finish dates, important milestones):
July 1997 to June 2000
Milestones:

April 1998:	Project R&D Team and collaborating network established. Regional facilitator recruited. Regional Coordination Committee (RCC) and Project Secretariat (PS) established with clear terms of reference. Communication strategy prepared and being implemented. Project performance criteria established. Regional stakeholder groups (RSGs) identified; self-evaluations completed; Planning Agreements signed. Regional resource use issues, objectives and preliminary strategies identified. Initial information needs assessed and potential role of information technology tools to assist resource planning evaluated.

December 98	RSGs preliminary regional strategies identified; first Regional Priorities Forum completed; new planning agreements reviewed and signed off; self assessment of preliminary strategies completed; agreed framework for negotiation established. Regional information system on resource use/management established; Preliminary report on region's resources completed; existing data and R&D audit complete; inventory of administrative environment, services and planning activities completed. First evaluation of information needs, changes to decision making processes and use of IT, completed. Assessment negotiated by the regional stakeholder options developed and negotiated by the regional stakeholder groups. Project performance criteria revised by RCC.
June 1999	Assessment of the strategic resource use options proposed by RSGs completed and results provided to RSGs and RCC. RSGs detailed strategies and R&D priorities established. Agreed regional strategies identified at second Regional Priorities forum. Initial draft implementation process and sustainability performance criteria developed for the agreed regional strategies. Interim assessment of project's performance and future work plan completed.
June 2000	Assessment of further or revised resource use options completed and results provided to RCC and RSGs. Regional information system, audits and inventories updated and completed. Evaluation of IT tools and methods, and planning/negotiation processes completed. RSGs have completed revised priorities and strategies; third regional forum has provided revised, agreed regional strategies for resource use. Implementation process developed in detail with performance indicators. Formal evaluation of project by RCC completed; strategies for the future of regional planning activities developed.

Funding sources:

CSIRO Tropical Agriculture:	$350 000 p.a
LWRRDC	$550 000 total
DNR	$141 000 p.a.
DFYCC	$135 000
DPI	$30 000 p.a.
DME	$65 000 total
DOE	$5 000 total
Premiers	$15 000

Brief summary and findings to date (max. 250 words):
To date, the project has explored the following key issues:

- The capacity of regional stakeholders to undertake effective regional planning;
- The nature of integration of planning activities occurring within the Central Highlands;
- The information needs of regional stakeholders and potential opportunities for establishing an overarching Information Technology System which incorporates web-based information sources and decision support tools;
- Development of a project evaluation methodology;
- Exploration of potential mechanisms for the developing effective State of the Region reporting systems for regional resource use planning.

Summary of methods (max. 250 words):
Given limitations in the current systems of regional planning in Australia, it would be unfortunate if new attempts to deal with regional issues in rangelands do not progress from the strengths and weaknesses of previous regional resource use planning experiments. The project seeks to establish and to evaluate the outcomes from a more communicative approach to regional planning for sustainable resource use. This project aims to set up a more regionally-driven approach which can explore a range of issues of relevance to the sustainable use of the region's natural resources.

After negotiations with key regional stakeholders this project is designed to address the sustainable use of land and resources in the region by:

1. directly supporting regional groups of resource users (e.g., the pastoral sector. The conservation sector, etc.) to do their own regional planning with respect to the sustainable resource use;
2. supporting these regional groups to get together in a structured way to negotiate regional solutions to common natural resource use problems; and
3. researching what regional planning techniques and processes best suit the communicative planning paradigm and the planning needs of regional stakeholder interests.

Planning support is to be provided to regional stakeholder groups on a voluntary basis rather than a planning process being imposed. It is not intended that a single "regional plan" will result, though one could emerge if negotiated by key regional groups. Instead, the project aims to assist each regional stakeholder group to work through its response to the variety of regional pressures that they face in managing their resources sustainably. Additionally, it also establishes key structures for encouraging enhanced interaction and opportunities for negotiation among regional stakeholders.

Research project proforma No. 35 - NAP3 scoping study

Title of project:
Decision support systems for natural resource management

Organisation(s) responsible (name, address, phone, fax, email):
CSIRO Tropical Agriculture

Project contact (name, address, phone, fax, email):
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Location of research:
The methods under development are derived from work in the Herbert Catchment of north Queensland and are primarily being trialled in that catchment

Objectives (dotpoints):
To develop effective methods for integrating biophysical and socio-economic research outputs into resource planning processes at a catchment scale through :

- The collation and synthesis of data sets and analytical tools (models, knowledge bases etc) relevant to resource evaluation and planning at a catchment scale
- The development of an innovative decision support toolkit environment that enables planners to combine those data and analytical resources to meet their particular requirements
- Capacity building at a local level to enable use of these resources
- The facilitation of participatory planning processes to use these resources

Expected outcomes and implications for the grazing industry (dotpoints):
While the software and methods developed have focussed to data on a catchment dominated by the sugar industry, the techniques used, participatory frameworks developed and software environment could be applied rapidly in areas in which grazing is the dominant land use.

Time lines (start, finish dates, important milestones):
The software toolkit environment (NRM Tools) is nearing the end of a major implementational phase and will be available for operational application in the next few months.

Evaluation of some of the key capacity building activities within the trial catchment near completion.

The tools and methods will be used on a trial basis to inform and facilitate planning negotiations this year (eg. work with an ICM committee looking at options for strategies on riparian vegetation)

Funding sources:
CSIRO Appropriations, SRDC, Sugar CRC

Brief summary and findings to date (max. 250 words):
Because this work is aimed at methodological development, findings relate to methodological requirements and the comparative efficacy of alternate approaches and, therefore, are probably not relevant here.

Summary of methods (max. 250 words):

Rigorous needs analysis : both as a basis for designing the functionality of the decision support toolkit environment (NRM Tools) and for designing the specific functional content of NRM Tools as delivered in the context of the Herbert Catchment.

Capacity building : Collaborative work with a range of stakeholders designed to build local capacity to use the integrated biophysical and socio-economic research outputs delivered through NRM Tools, eg. core involvement in the establishment of the Herbert Resource Information Centre (HRIC), a collaborative joint venture between industry, local, sate and Federal government and the local community that provides for collaborative capture ad use of key resource data.

Participatory methods : Both in the development of the methods and tools under construction and in their use through a planning systems approach to integrated resource management.

Evaluation : Application of qualitative and quantitative methods for the evaluation of the impact of use of the tools and methods developed and of participation in their development both on processes of planning and on outcomes.

Research project proforma No. 36 - NAP3 scoping study

Title of project:
Groundwater resources of the Balfes Creek Catchment.

Organisation(s) responsible (name, address, phone, fax, email):
- DNR:- CO/ Rob Lait(formally DPI), PO Box 1054 Mareeba, (07) 40928555
- CSIRO:- CO/ Elisabeth Bui, contact Christian Roth, Davies Lab Townsville, (07) 47538569

Project leader/contact (name, address, phone, fax, email):
•Matthew Stenson, Tropical Weeds Research Centre, Natal Downs Road, Charters Towers, tel (07) 47873300, fax (07) 47873969, Matthew.Stenson@dnr.qld.gov.au
Formally Jason Keys, ex DNR.

Location of research:
•Balfes Creek Catchment, approximately 25 km south west of Charters Towers.

Objectives (dotpoints):
•The project was developed to collect more detailed hydrogeological data for use in identifying areas at risk of dryland salinity in the Balfes Creek Catchment.
•To locate existing bores in the Balfes Creek Catchment, and combine with existing data from mining and exploration companies.
•To log and sample bores and compare with historic records where available.
•To interpret data as a hydrogeological map with aquifer characteristics and identify potential resource and risk areas.
•To use the information for the salinity hazard risk assessment of the catchment to determine appropriate vegetation management strategies.

Expected outcomes and implications for the grazing industry (dotpoints):
•A sound basis for planning future research and development.
•Identification of resource potential and salinity risk for the catchment.
•Input into vegetation management strategies for the catchment.

Time lines (start, finish dates, important milestones):
Commenced June 1996; final report December 1997

Funding sources:
•LWRRDC/DNR/CSIRO

Brief summary and findings to date (max. 250 words):
•The project has identified and collated data from approximately 300 bores in the catchment, 150 of which where sampled for the first time during this project. The data has been collated and organised into a GIS data base along with soil, vegetation, geology, topographic and cadastral data, and satellite images.
From this data a piezometric surface was constructed showing the general direction of groundwater flow, and identifying potential recharge and discharge areas. Flow direction when combined with local water table heights, aquifer characteristics, water quality (measured as conductivity), soil type and conductivity, geomorphology, and vegetation coverage has allowed a hazard map of the area to be developed. The hazard map will be used to develop vegetation management strategies for clearing, and identify areas most at risk, which will lead to recommendations on remediation and control of water table heights in areas of high risk.

Summary of methods (max. 250 words):
•Locate, log and sample existing bores on properties and add data to existing data bases.
•Compare with historic data where available.
•Locate existing mining exploration and bore driller records and compare with collected data.
•Produce preliminary aquifer, water quality and water table elevation maps, related to soils and geology.
•Relate project results to recharge and produce a final report on the groundwater resources and potential usage, and salinity risks.

Research project proforma No. 37 - NAP3 scoping study

Title of project:
"State of the Rivers - An Ecological and Physical Assessment of rivers and streams in Queensland"

Organisation(s) responsible (name, address, phone, fax, email):
Department of Natural Resources
Resource Sciences Centre
Block B, 80 Meiers Road
INDOOROOPILLY QLD 4068

ph: 07 38969521 fax: 07 38969525
email: mollerg@dnr.qld.gov.au

Project leader/contact (name, address, phone, fax, email):
Glen Moller (details same as above)

Location of research:
Statewide

Objectives (dotpoints):
- to describe the ecological and physical condition of Queensland's watercourses.
- establishment of a baseline for follow up surveys and hence long term monitoring of watercourse condition.
- strategic issue identification and prioritisation for riverine corridors and instream habitats

Expected outcomes and implications for the grazing industry (dotpoints):
- identifies areas where grazing activities are a major disturbance affecting stream and riparian attributes.

Time lines (start, finish dates, important milestones):
- Since the development of the methodology ten catchments have been surveyed across the state. The results of six of these have been published: Maroochy River, Upper Condamine River, Dawson River, Herbert River, Mary River and Lockyer Creek.
- The Bremer River, Tully River, and Cooper Creek reports are in draft and data analysis is being carried out on the Border Rivers catchment. All reports are expected to be published by the end of '98.
- Preparations are under way for a survey in the Mooloolah River/Pumicestone passage catchments and proposals have been submitted to undergo a survey in the Burnett River catchment.

Funding sources:
NHT funds

Brief summary and findings to date (max. 250 words):
Although these ten catchments are very different, the results of the surveys have shown that the majority of our streams are in moderate to poor condition. In most cases, poor condition ratings were associated with management practices within the riparian zones; grazing and intensive agriculture.

The stream reach environs and riparian zone have undergone very high disturbance and degradation; vegetation has been cleared and exotic species have invaded in association with various grazing activities and intensive agriculture.

Management practices within the riparian zone and reach environs of the streams should focus on minimising further degradation and rehabilitating and revegetating of degraded areas.

Retention and management of all existing areas of riparian vegetation should be promoted, and the re-establishment of riparian vegetation along streams should be encouraged, particularly where stream bank erosion could occur. Additionally, the clearing of vegetation within the riparian zones along watercourses should be restricted.

Although both the stream beds and stream banks are predominantly stable, some erosion was apparent along almost all stream banks. Attempts should be made to maintain stability and stabilise problem areas, particularly those prone to slumping and where the erosion problems are of critical importance to catchment health.

In most cases, poor condition ratings and bed and bank instability were associated with cattle grazing in the area. Minimisation of grazing in stream environs and the riparian zone is essential for the maintenance and improvement of the catchment's present condition and for rehabilitation of degraded areas.

Summary of methods (max. 250 words):
The 'State of the Rivers' methodology provides a comprehensive method for classifying the current physical and ecological condition of rivers and streams. The basis of the classification is to divide the catchment under investigation into 'homogeneous stream sections' that share similar natural features and conditions. The delineation of these homogeneous stream sections involves a progressive division of the catchment into smaller and smaller units.

Initially the catchment is divided into major subcatchments, each of which will have different or unique characteristics that influence the stream morphology within that particular area. A variety of information is used to divide streams into homogeneous sections that will reasonably quickly provide an accurate description of the stream systems.

Attributes such as soil type and geology, vegetative cover, stream bank slope, stream gradients and sediment types are used to help determine the homogeneous stream sections. Boundaries for subsections may be located at natural barriers (such as waterfalls and wetlands), artificial barriers (such as dams and weirs), or positions where major changes to attributes are likely to affect the natural features of the streams or their condition. In order to confirm the initial homogeneous stream sections and to select appropriate survey sites, the area is reconnoitered before the main survey takes place.

Survey sites generally are selected both to represent the stream section and to allow relatively easy access, thus minimising time and expense of carrying out each site survey. Sites are commonly situated upstream of road crossings or within reasonable walking distance of access tracks. Every effort is made to ensure that survey sites are clear of disturbances associated with access points, except, of course, where an access point has become a representative feature of the stream's condition (e.g. sites at weirs).

PROJECT DESCRIPTION FOR BEEFPLAN

Project Title: BEEFPLAN

Project Reference Number: NAP3.310

Project Location: Various (North Australia)

Project Start Date: 01/03/98
Project End Date: 30/06/01

Applicant Organisation: Individual BEEFPLAN Groups (see individual contracts)

Address: PO Box 852, Kuranda. 4872.

Administrative Contact: Steve Banney

PART 2: THE PROJECT

Description:
The project recognises that beef producers are business people using their knowledge and experience manage their properties for profit. BEEFPLAN intends to build on that base by developing management systems that enable the appropriate application of a mix of technologies and principles, information and opportunities to the business.

The project seeks to achieve the full benefits of research and development work by evolving implementation strategies that bring together current information and new research results in ways that will clearly enhance profitability and sustainability.

Key goals include:
- integrated property management,
- driven and owned by producers, and,
- the creation of linkages to extend the process to other producers and supporting agencies and businesses.

To achieve these goals, up to 5 groups of producers and allied management and technical advisers will be established across northern Australia (Qld. NT, Kimberley and Pilbara) to develop an integrated systems approach to whole property management.
The BEEFPLAN project will improve long-term sustainability and prosperity of northern beef producers by:

- developing an understanding of, and strategies for, integrated beef property management across the various northern Australian beef production systems,
- developing systems which can effectively integrate both production and resource management in an equitable way,
- improving the understanding of whole farm systems among producers, researchers, extension officers, and agribusiness personnel to enhance their knowledge, management and decision making skills,
- establishing a whole-farm focus across the industry and within supporting agencies and businesses,
- developing new opportunities for beef producers through better integration of components of whole-farm systems,
- fostering a collaborative community/regional approach to developing integrated management systems,
- identifying the most successful strategies and approaches developed by the producer groups and extending these processes widely throughout the northern beef industry,
- providing ownership to the northern producers of this whole property initiative.

Objectives:
By June 2001-

- To establish 5 groups with a total of 150 producers adopting integrated management principles and skills.
- For individual core BEEFPLAN members to measure an improvement in their financial performance, which is linked to their involvement in BEEFPLAN,
- For individual BEEFPLAN core members to have adopted (more) resource management practices that will (maintain or) improve the condition of vegetation/soil resources on their properties.

- To undertake strategic R&D to monitor, analyse and evaluate the various approaches, strategies and processes used by the different groups, determining which are successful and why.
- To then develop principles, methodologies, practices and information systems for integrated whole property management, which can be readily adapted and provided to producers across northern Australia.
- To have at least 1,000 producers initiating BEEFPLAN activities as a result of the core management project.

Within the context of these overall objectives, each of the five core groups will develop specific measurable objectives to be achieved by June 2001.

Methodology:
The project is designed to apply to beef producers of all sizes. Large, integrated cattle operations stand to benefit as much as their smaller contemporaries, through better integration of various production/environmental/marketing options.

Core Groups
Under Stage One of the BEEFPLAN project, an initial call was made for producer groups across northern Australia to submit a short project proposal outlining how their group will manage a project in their area. From these applications, up to five groups are to be selected, representing various geographic and production areas.

The groups themselves could be drawn from a number of backgrounds such as established producer groups from within Landcare, marketing groups, Beef Improvement Association, Regional Beef Research Committee, Producer Demonstration Site, Best Practice, or from other special purpose groups formed specifically to take part in the program.

Each of the five selected groups may then utilise specialist consultants from a range of fields including business management (business systems and comparative analysis); and technical management (productivity, marketing, resource management, and other areas of R&D) to develop a full and detailed proposal. Detailed methodologies for the five core groups will be provided to MLA as a basis for individual group agreements.

This process of project development could take some months and a degree of seed funding could be allocated to assist with this process. Substantial funding will be provided by NAP3 to fund a part-time group coordinator, consultant specialists, project operation and communication activities.

It is intended that the consultants contributing to the local projects will be drawn from a mix of private and agency backgrounds, strengthening the linkages and networks within that sector. It is anticipated that each group would involve 10-20 families or property managers, each of whom would involve their properties, and provide access to their records for the program.

While project activities and identification of priorities and their relative importance will vary from group to group, the following issues are considered integral to the project::
- Group strategy and direction, including ongoing project evaluation and reporting,
- Business management and planning systems including the identification and management of key profit drivers
- Resource management planning to maintain and enhance the health and biodiversity of the resource base.
- To increase awareness of social dimensions of all aspects of the business and its relations to the operating commercial and natural environments.

Other issues, by no means an exhaustive list, which may be considered are:

- an inventory of current production/management systems, practices, skills, etc
- development of benchmarking and comparative analysis
- resource, production and economic monitoring of whole-farm systems
- business planning
- managing total grazing pressure
- family, community and social issues and impacts
- establishment and use of case studies
- assessment and use of decision support systems
- skills training and enhancement, action learning programs
- communication and extension
- risk assessment and management

Close linkages will be developed between the five groups. Participants will be required to show commitment to the project's strategic direction, a willingness to adopt tactical and strategic changes in management and contribution to the extension of these principles to other producers outside the core project is essential.

8.5 Result documentation of the assessment of intrinsic vulnerability

Table 8.5A: Compilation of results from GIS analysis to assess the intrinsic vulnerability of Northern Australian catchments to sheet and rill erosion {area calculated from coverage polygons; index calculated from equation 1; STDEV = standard deviation of indices within catchment polygon; sum of indices = sum of all grid values within catchment polygon; grid resolution = 1000 x 1000 m}

Name of Division	Catchment Name	Area (km^2)	Index range	Mean index	STDEV index	Median index	Sum of indices
Gulf of Carpentaria	Archer River	13740	302	4.1	6.1	2.2	56807
"	Calvert River	10046	44	3.6	3.6	2.5	35942
"	Coleman River	12988	149	2.6	4.0	1.4	33658
"	Ducie River	6286	42	3.1	4.2	1.5	19331
"	Embley River	3923	15	1.2	1.0	0.9	4688
"	Flinders River	109434	104	2.2	3.4	1.3	242437
"	Gilbert River	46218	94	3.5	4.7	1.8	160051
"	Holroyd River	10225	136	1.8	3.5	0.6	18454
"	Jardine River	3136	70	6.1	6.1	4.4	19254
"	Koolatong River	7072	73	3.4	4.9	1.9	24307
"	Leichardt River	33242	67	3.9	4.7	2.0	128465
"	Limmen Bight River	15731	56	3.3	3.7	2.0	51824
"	Mcarthur River	18783	55	3.8	3.7	2.6	70794
"	Mitchell River	71321	545	5.1	7.8	2.0	367239
"	Morning Inlet	3511	23	1.7	1.5	1.6	5892
"	Nicholson River	52105	69	2.7	3.5	1.5	141306
"	Norman River	50234	65	1.5	3.1	0.7	74721
"	Robinson River	11714	37	3.3	3.0	2.4	38120
"	Roper River	78059	106	2.9	4.2	1.4	225638
"	Rosie River	5316	45	2.9	4.6	1.2	15435
"	Settlement Creek	16854	78	4.2	5.4	2.4	71101
"	Staaten River	25788	31	1.5	1.6	1.2	38742
"	Towns River	5398	31	2.2	2.6	1.3	11986
"	Walker River	9268	61	3.5	4.3	2.1	32007
"	Watson River	4557	19	1.3	1.0	1.0	5774
"	Wenlock River	7300	301	2.9	5.3	1.3	21075
Indian Ocean	Ashburton River	74430	70	2.8	4.3	1.3	206363
"	De Grey River	56131	85	2.6	3.9	1.2	145441
"	Fortescue River	48317	92	3.7	5.8	1.4	179162
"	Gascoyne River	4411	21	1.2	1.4	0.7	5153
"	Lyndon-Minilya Rivers	12896	45	1.0	1.5	0.6	13018
"	Onslow Coast	16901	55	3.3	4.5	1.4	56074
"	Port Hedland Coast	34341	82	4.3	6.2	1.4	146292
Lake Eyre	Diamanthina River	720573	64	1.0	1.2	0.7	736495
"	Finke River	43134	70	1.7	3.0	0.8	73474
"	Todd River	58113	44	1.2	2.3	0.4	68778
Murray-Darling	Border Rivers	23688	70	1.7	2.9	0.9	40893
"	Condamine-Culgoa Rivers	132227	237	1.2	2.3	0.5	159502
"	Moonie River	14328	18	0.8	1.0	0.4	11795
"	Paroo River	33007	19	0.8	0.8	0.6	27915

"	Warrego River	56335	50	1.5	1.9	0.9	81791
North-East Coast	Baffle Creek	3796	86	5.1	7.7	2.0	19536
"	Barron River	2112	147	4.9	8.0	1.5	10375
"	Black River	1037	500	6.1	9.5	1.9	6304
"	Boyne River	2446	83	9.0	9.2	5.6	22028
"	Brisbane River	13573	407	4.3	5.4	2.5	58103
"	Burdekin River	130042	367	2.9	5.0	1.3	378552
"	Burnett River	33262	127	3.1	3.5	2.0	101552
"	Burrum River	3223	30	1.1	2.1	0.3	3632
"	Calliope River	2156	143	6.8	7.7	3.9	14741
"	Daintree River	1862	151	1.3	3.0	0.6	2505
"	Don River	3409	239	7.4	9.1	3.2	25138
"	Endeavour River	2032	605	15.3	13.0	11.2	31190
"	Fitzroy River	142389	103	2.7	4.1	1.4	390679
"	Fraser Island	1383	83	6.9	8.4	2.8	9587
"	Haughton River	4185	463	6.7	10.7	1.3	28034
"	Herbert River	9713	91	2.3	3.7	1.0	21883
"	Jacky Jacky Creek	2512	100	4.5	5.9	2.2	11327
"	Jeannie River	3444	333	14.5	12.0	9.4	49919
"	Johnstone River	2234	27	1.2	2.2	0.6	2792
"	Kolan River	2857	103	3.9	5.3	2.2	11222
"	Lockhart River	2721	396	9.0	11.1	4.8	24449
"	Logan-Albert Rivers	4121	99	4.8	6.1	2.7	19865
"	Maroochy River	1423	633	4.4	8.0	1.0	6298
"	Mary River	9395	129	4.2	5.1	2.4	39139
"	Mossman River	514	76	2.2	3.7	0.9	1110
"	Mulgrave-Russell River	1906	72	1.8	3.5	0.6	3382
"	Murray River	1016	484	4.1	7.2	1.7	4209
"	Noosa River	1771	49	4.8	6.1	2.4	8433
"	Normanby River	24536	648	7.5	10.8	1.9	184873
"	Oconnell River	2272	222	5.9	8.8	2.0	13517
"	Olive-Pascoe River	4008	496	9.0	10.5	4.0	35914
"	Pine River	1455	93	4.5	6.8	1.6	6588
"	Pioneer River	1561	103	2.0	3.6	0.8	3075
"	Plane Creek	2380	80	2.1	3.7	0.7	4962
"	Proserpine River	2351	539	6.6	9.2	3.1	15604
"	Ross River	1319	607	10.0	11.7	3.5	13243
"	Shoalwater Creek	3428	232	4.4	6.6	2.0	15241
"	South Coast	1250	181	5.9	9.2	1.2	7341
"	Stewart River	2648	325	5.9	7.3	3.5	15629
"	Styx River	2961	82	3.8	6.3	1.5	11341
"	Tully River	1582	343	4.0	8.2	0.7	6276
"	Water Park Creek	1495	240	8.9	9.9	4.7	13355
Timor Sea	Adelaide River	7258	84	3.7	5.1	2.1	27040
"	Blyth River	9164	56	1.4	2.2	0.8	12446
"	Buckingham River	7989	25	1.7	2.1	0.8	13485
"	Cape Leveque Coast	17057	17	1.5	0.9	1.3	24852
"	Daly River	51311	120	2.9	4.0	1.6	147619
"	Drysdale River	25117	59	2.4	2.4	1.7	60448
"	East Alligator River	14779	46	1.1	2.5	0.4	16037
"	Finniss River	9228	85	4.0	5.2	2.3	36720
"	Fitzmaurice River	10262	124	4.8	7.0	2.2	49329

"	Fitzroy River	91243	146	3.3	4.8	1.6	302803
"	Goomadeer River	5553	35	1.4	2.2	0.7	7885
"	Goyder River	9120	77	3.3	3.5	2.3	30154
"	Isdell River	19158	156	7.1	8.6	3.4	136800
"	Keep River	11411	75	3.0	5.4	0.9	34516
"	King Edward River	17032	87	4.5	5.3	2.5	77388
"	Lennard River	14276	122	5.1	7.1	2.0	73421
"	Liverpool River	8600	21	1.2	1.6	0.6	9959
"	Mary River	7805	122	3.8	4.9	2.2	29423
"	Moyle River	7745	74	3.5	4.7	2.3	27355
"	Ord River	55247	149	5.9	6.9	3.3	326032
"	Pentecost River	27479	115	4.7	5.1	3.1	129626
"	Prince Regent River	14769	98	5.2	5.6	3.4	77324
"	South Alligator River	11659	106	2.9	5.7	0.7	33852
"	Victoria River	75687	233	4.6	5.5	2.7	349139
"	Wildman River	4789	13	0.8	1.1	0.4	3763
Western Plateau	Barkly	125796	23	0.9	0.8	0.7	109053
"	Burt	42006	83	1.1	2.6	0.5	47000
"	Mackay	412818	65	0.7	1.1	0.5	287755
"	Salt Lake	76173	15	0.4	0.4	0.3	32690
"	Sandy Desert	395191	26	0.6	0.5	0.5	241592
"	Warburton	10051	22	0.5	0.9	0.3	4820
"	Wiso	243276	44	0.8	0.9	0.6	198960

Table 8.5B: Compilation of results from GIS analysis to assess the intrinsic vulnerability of Northern Australian catchments to gully and channel erosion {area calculated from coverage polygons; index calculated from equation 1; STDEV = standard deviation of indices within catchment polygon; sum of indices = sum of all grid values within catchment polygon; grid resolution = 1000 x 1000 m}

Name of Division	Catchment Name	Area (km^2)	Index range	Mean index	STDEV index	Median index	Sum of indices
Gulf of Carpentaria	Archer River	13784	120	2.7	5.4	0.9	37590
"	Calvert River	10066	46	1.1	1.5	0.6	10691
"	Coleman River	12975	96	1.1	2.4	0.4	14811
"	Ducie River	6250	6	0.9	0.6	0.7	5474
"	Embley River	4117	7	0.7	0.6	0.5	2805
"	Flinders River	109462	20	0.4	0.8	0.1	39338
"	Gilbert River	46297	40	1.5	2.0	0.8	68704
"	Holroyd River	10220	104	1.2	2.8	0.6	12363
"	Jardine River	3254	8	1.3	0.9	1.1	4279
"	Koolatong River	7057	48	2.4	3.5	1.3	17241
"	Leichardt River	33301	37	1.0	1.5	0.3	32200
"	Limmen Bight River	15748	24	1.0	1.6	0.5	15904
"	Mcarthur River	18801	15	0.9	1.1	0.5	16401
"	Mitchell River	71372	234	2.6	5.1	0.8	188333
"	Morning Inlet	3574	3	0.2	0.2	0.1	716
"	Nicholson River	52155	24	0.7	1.1	0.3	35666
"	Norman River	50255	15	0.4	0.7	0.2	19219
"	Robinson River	11747	14	1.0	1.1	0.7	11670
"	Roper River	78052	46	1.0	1.8	0.3	75660
"	Rosie River	5359	31	1.8	2.8	0.8	9821
"	Settlement Creek	17075	31	0.9	1.8	0.2	15424
"	Staaten River	25819	10	0.3	0.4	0.2	7834
"	Towns River	5412	11	0.8	0.9	0.5	4163
"	Walker River	9291	49	2.2	2.8	1.3	20565
"	Watson River	4552	5	0.9	0.6	0.7	3981
"	Wenlock River	7278	173	2.7	5.4	1.0	19448
Indian Ocean	Ashburton River	74437	36	1.1	1.6	0.5	79318
"	De Grey River	56228	38	0.8	1.2	0.5	46672
"	Fortescue River	48346	24	0.9	1.7	0.3	43966
"	Gascoyne River	4411	11	0.5	0.8	0.2	2045
"	Lyndon-Minilya Rivers	13027	27	0.4	1.1	0.1	4735
"	Onslow Coast	16939	19	1.0	1.3	0.5	16223
"	Port Hedland Coast	34518	27	1.2	1.5	0.6	39829
Lake Eyre	Diamanthina River	720223	11	0.1	0.3	0.1	104374
"	Finke River	43134	29	0.8	1.5	0.3	32964
"	Todd River	58113	21	0.3	0.8	0.1	19318
Murray-Darling	Border Rivers	23684	51	1.3	2.3	0.6	29908
"	Condamine-Culgoa Rivers	132205	64	0.6	1.5	0.2	78842
"	Moonie River	14328	7	0.3	0.4	0.2	4825
"	Paroo River	32960	5	0.1	0.2	0.1	3627
"	Warrego River	56335	13	0.2	0.4	0.1	10824
North-East Coast	Baffle Creek	3859	167	6.4	8.7	2.7	24786

"	Barron River	2076	188	8.8	10.0	4.2	18354
"	Black River	1047	306	12.2	12.3	6.9	12798
"	Boyne River	2441	124	12.4	9.7	9.2	30355
"	Brisbane River	13579	172	8.2	9.1	4.6	111803
"	Burdekin River	129135	289	1.9	4.6	0.5	245388
"	Burnett River	33271	59	2.7	3.3	1.7	89575
"	Burrum River	3312	22	1.2	1.6	0.6	3909
"	Calliope River	2163	55	5.4	5.9	3.2	11725
"	Curtis Island	462	11	1.1	1.4	0.5	504
"	Daintree River	1849	390	23.6	11.0	31.0	43681
"	Don River	3451	104	5.8	8.1	2.3	19910
"	Endeavour River	2031	277	17.2	12.6	15.4	34838
"	Fitzroy River	142410	198	2.3	4.3	0.8	321815
"	Haughton River	4253	261	6.1	9.7	1.4	26014
"	Herbert River	9704	353	6.3	9.6	1.7	61332
"	Jacky Jacky Creek	2577	18	1.2	1.1	0.8	2974
"	Jeannie River	3522	185	8.5	11.1	2.5	29830
"	Johnstone River	2230	848	16.2	12.8	12.4	36207
"	Kolan River	2888	205	7.6	8.3	4.6	21943
"	Lockhart River	2781	223	9.5	11.0	3.9	26455
"	Logan-Albert Rivers	4117	311	10.1	10.4	5.7	41611
"	Maroochy River	1391	100	7.3	9.1	3.2	10100
"	Mary River	9374	95	5.8	7.1	3.2	54442
"	Mossman River	515	382	16.5	13.1	13.0	8483
"	Mulgrave-Russell River	1827	990	17.2	13.7	14.7	31352
"	Murray River	1007	357	14.9	14.1	7.8	15007
"	Noosa River	1719	50	2.1	4.6	0.5	3582
"	Normanby River	24622	321	5.5	9.3	0.7	134199
"	Oconnell River	2286	244	15.6	12.4	12.0	35622
"	Olive-Pascoe River	4125	176	6.4	8.6	2.4	26239
"	Pine River	1431	79	7.7	9.0	4.1	11004
"	Pioneer River	1558	246	17.8	11.9	15.4	27701
"	Plane Creek	2396	225	7.8	9.0	4.0	18621
"	Proserpine River	2418	202	12.2	12.0	5.8	29424
"	Ross River	1326	298	10.7	11.5	4.9	14122
"	Shoalwater Creek	3524	140	5.2	7.8	1.9	18366
"	South Coast	1250	437	17.7	13.8	17.3	22173
"	Stewart River	2664	176	5.6	9.1	1.4	15028
"	Styx River	2971	94	6.2	8.8	2.3	18501
"	Tully River	1582	739	17.3	13.0	13.8	27332
"	Water Park Creek	1542	132	4.3	7.0	1.7	6674
Timor Sea	Adelaide River	7337	52	0.9	1.9	0.4	6302
"	Blyth River	9323	22	1.7	1.7	1.2	15528
"	Buckingham River	8564	32	1.8	2.4	0.9	15376
"	Cape Leveque Coast	17333	13	0.5	0.7	0.3	8560
"	Daly River	51352	75	0.8	1.7	0.3	41786
"	Drysdale River	25251	25	1.0	1.4	0.6	25922
"	East Alligator River	15081	47	1.4	2.8	0.4	20948
"	Finniss River	9459	50	1.0	1.7	0.4	9055
"	Fitzmaurice River	10301	117	3.1	5.4	1.2	31555
"	Fitzroy River	91308	43	0.8	1.4	0.3	69291
"	Goomadeer River	5674	29	1.5	2.1	0.8	8573
"	Goyder River	9165	44	2.3	2.6	1.6	20921
"	Isdell River	19466	59	2.9	4.6	1.2	56054
"	Keep River	11494	31	0.8	1.7	0.2	9671
"	King Edward River	17252	70	1.7	2.6	0.8	28507

"	Lennard River	14339	40	1.4	2.7	0.4	19371
"	Liverpool River	8671	35	2.3	2.8	1.4	19989
"	Mary River	7867	52	1.2	1.8	0.6	9273
"	Moyle River	7815	38	0.9	2.1	0.3	6672
"	Ord River	55277	165	1.8	3.3	0.8	96949
"	Pentecost River	27541	52	1.8	2.5	1.1	50876
"	Prince Regent River	14945	76	2.9	5.1	1.0	43474
"	South Alligator River	11778	62	2.3	4.0	0.8	26980
"	Victoria River	75787	86	1.6	3.4	0.5	120503
"	Wildman River	4911	15	0.6	0.8	0.4	3041
Western Plateau	Barkly	125796	10	0.1	0.3	0.0	11347
"	Burt	42006	18	0.2	0.6	0.0	7021
"	Mackay	412817	23	0.1	0.3	0.0	30268
"	Salt Lake	76173	2	0.1	0.1	0.0	5716
"	Sandy Desert	395301	6	0.0	0.1	0.0	15322
"	Warburton	10051	9	0.1	0.2	0.0	535
"	Wiso	243276	13	0.1	0.3	0.0	15655

affected. However, little quantitative information seems to be available. Ponded pastures is seen as a potential threat to some of the wetlands.

Water quality is also of concern, with nutrient concentrations and turbidity in the streams generally being high except at upper catchment locations (Chudek, 1995). This is due partly to natural processes but mainly because of inputs from various land use activities (irrigated cotton, mining, grazing). Consequently, algal blooms are a problem within major water bodies in the Fitzroy catchment, in particular within the Fitzroy River Barrage and Eden Bann Weir (Chudek, 1995).

Recent evidence suggests that the Fitzroy catchment, like the Burdekin, is one of the major contributors of sediments and nutrients to the Great Barrier Reef Lagoon (Wasson, 1997; Rayment and Neil, 1997; Mitchell and Furnas, 1997). There have certainly been increases since post-European settlement, but a great deal of uncertainty resides in the estimates, both with respect to sources as well as with respect to absolute amounts (Wasson, 1997; Rayment and Neil, 1997).

Representativeness of catchment to northern Australian landscapes
Overall, the Fitzroy catchment is fairly representative of the beef industry in northern Australia in terms of its diversity of landscapes and particularly so for great parts of central and north-eastern QLD. The large cattle herd carried in the catchment is more representative of the higher productivity regions in NA and would not reflect as well a major portion that is characterised by generally lower cattle densities. The Fitzroy catchment also offers the opportunity to compare the effects of different land uses in the same catchment and to link in with the National Eutrophication Management Program (NEMP).

Producer/community issues

Assessment of relevance of catchment to the beef industry
The Fitzroy catchment clearly ranks highest on the basis of its large cattle herd, supporting 2.29 million cattle on a catchment of area of approx. 145,000 km^2. This accounts for nearly 20 % of total cattle numbers in NA. The Fitzroy ranks 20^{th} in terms of cattle density, and as indicated in Fig. 6.10, forms part of group 2 with a moderate to high proportion of the catchment grazed and with high levels of productivity. Grazing is the major enterprise with approximately 75% of the catchment used, followed by 6% used for crop production and 1% used for mining. Other areas comprise forests and National Parks.

Producer awareness of erosion problem and off-site effects
In the process of developing the Central Queensland Strategy for Sustainability, the Fitzroy Basin Association conducted 14 community workshops to determine community issues in the catchment. Major concerns under the broad issue "Sustainable Land Management" were erosion, weed and pest management and tree and pasture management while under the broad issue of "Water and Riverine Management" river health monitoring and applied research were perceived to be the main issues.

Assessment of community / producer activities and involvement in catchment management
The Fitzroy catchment is characterised by a relatively high level of producer driven initiatives. The main body involved in catchment management is the Fitzroy Basin Association (FBA, formerly Fitzroy Catchment Co-ordinating Group), which is currently developing a Central Queensland Strategy for Sustainability. Priority issues identified include:

- sustainable land management (soil erosion, weed and pest, and tree and pasture management)

- water and riverine management (water quality, riverine health monitoring, water partnerships).
- rural enterprise viability (rural business skills, social / economic factors, diversification).
- habitat and biodiversity management (biodiversity, ripariation zones, rare / endangered species).

In addition, there are approximately 40 Landcare groups in the Fitzroy catchment. Seventy percent of these groups have National Landcare / Natural Heritage Trust funding including 20 funded Project Officers. An overview of current or planned NHT projects is given in Tab. 6.11. A large number of these projects are directed at regional planning and some of the priority issues include:

- erosion and land remediation
- water quality monitoring
- tree and pasture management
- increasing community awareness of natural resource management
- planning regional natural resource management.

Table 6.11: Overview of current and planned NHT funded projects within the Fitzroy catchment

Project	**Lead organization**	**Objective**	**Total project cost**
Bushcare			
Evaluation of Remnant Vegetation of Central and Eastern Queensland	Queensland Department of Environment	To complete the surveying and mapping of the preclearing and current extent of regional ecosystems in six bioregions in Eastern QLD	$663,499
Recommended Native Plants for the Fitzroy Catchment	Society for Growing Australian Plants	To publish a practical reference book that provides guidelines for choosing and growing native plants in the Fitzroy Catchment	$12,850
? Remnant Vegetation and Bird Communities in Central Queensland	Central Queensland University	To preserve and improve remnant vegetation in Central Queensland, to provide evidence of the importance of remnant vegetation to native animals and to determine the most appropriate size of remnant vegetation to conserve	$27,245
National Landcare Program			
Applied Soil Information for Sustainable Farming and Property Management Planning in Central Queensland	Queensland Department of Natural Resources	To increase awareness and knowledge of local soils and land management information by producers for decision making at the property level within the Fitzroy Catchment and Curtis Coastal area.	$354,393
Assessment of Natural Resource Condition in the Fitzroy Catchment	Queensland Department of Natural Resources	To improve the development, management, co-ordination and availability of natural resource information within the Fitzroy River catchment	$535,440
Co-ordinator for Landcare Group Activities	Callide Valley Landcare Association Inc.	To employ a project coordinator	$210,872

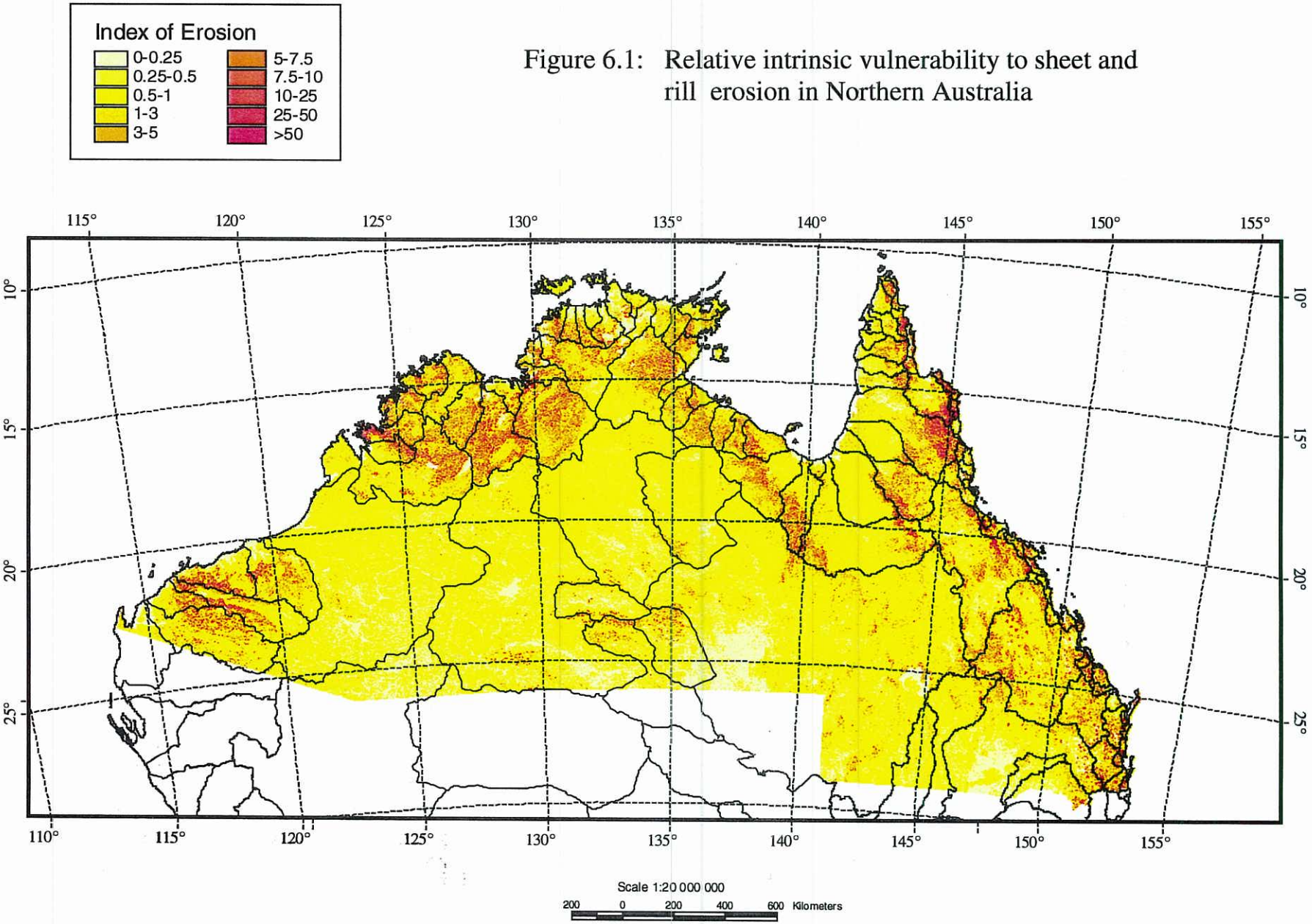


Figure 6.1: Relative intrinsic vulnerability to sheet and rill erosion in Northern Australia

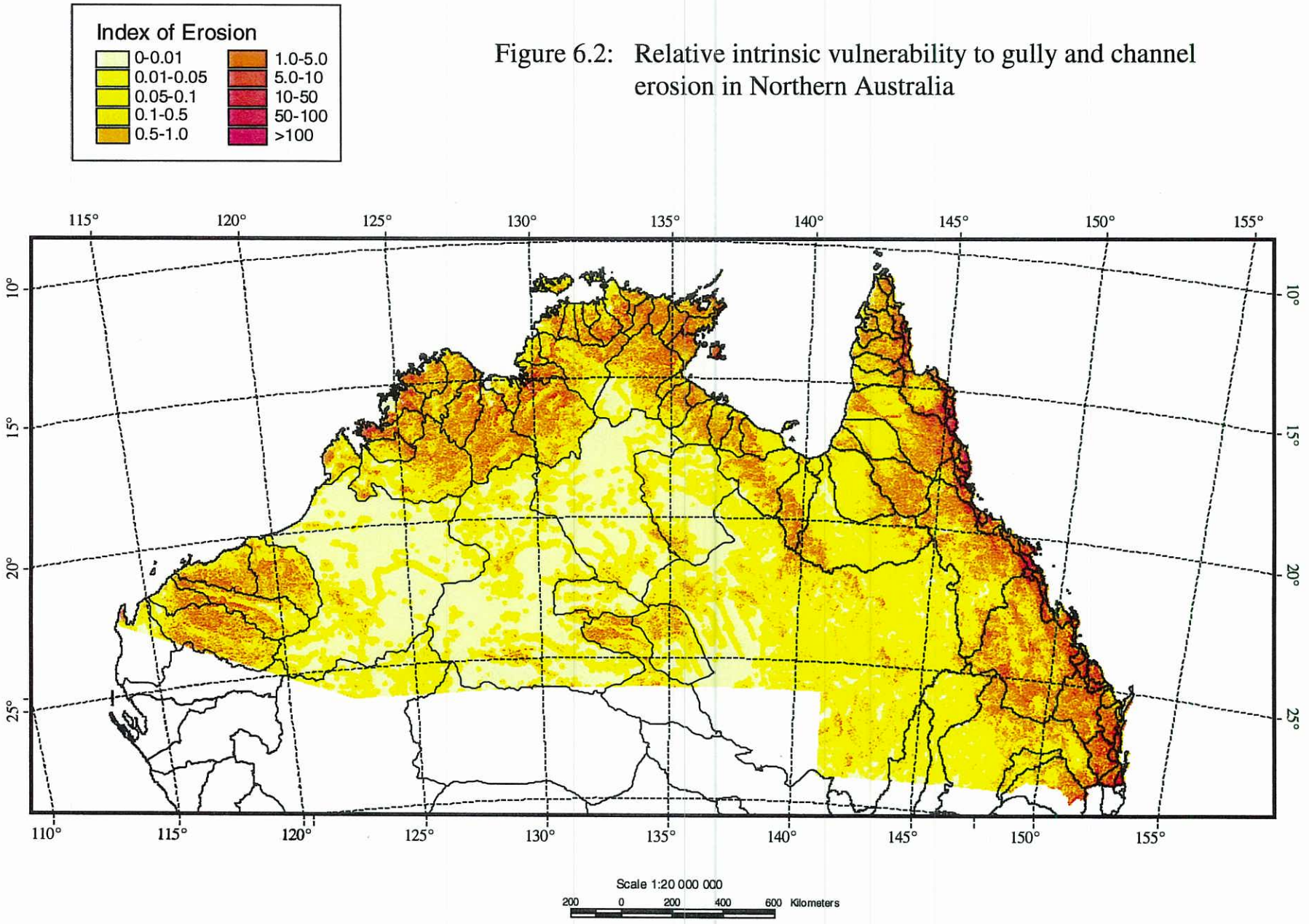


Figure 6.2: Relative intrinsic vulnerability to gully and channel erosion in Northern Australia

Figure 6.6. Shires - Northern Australia

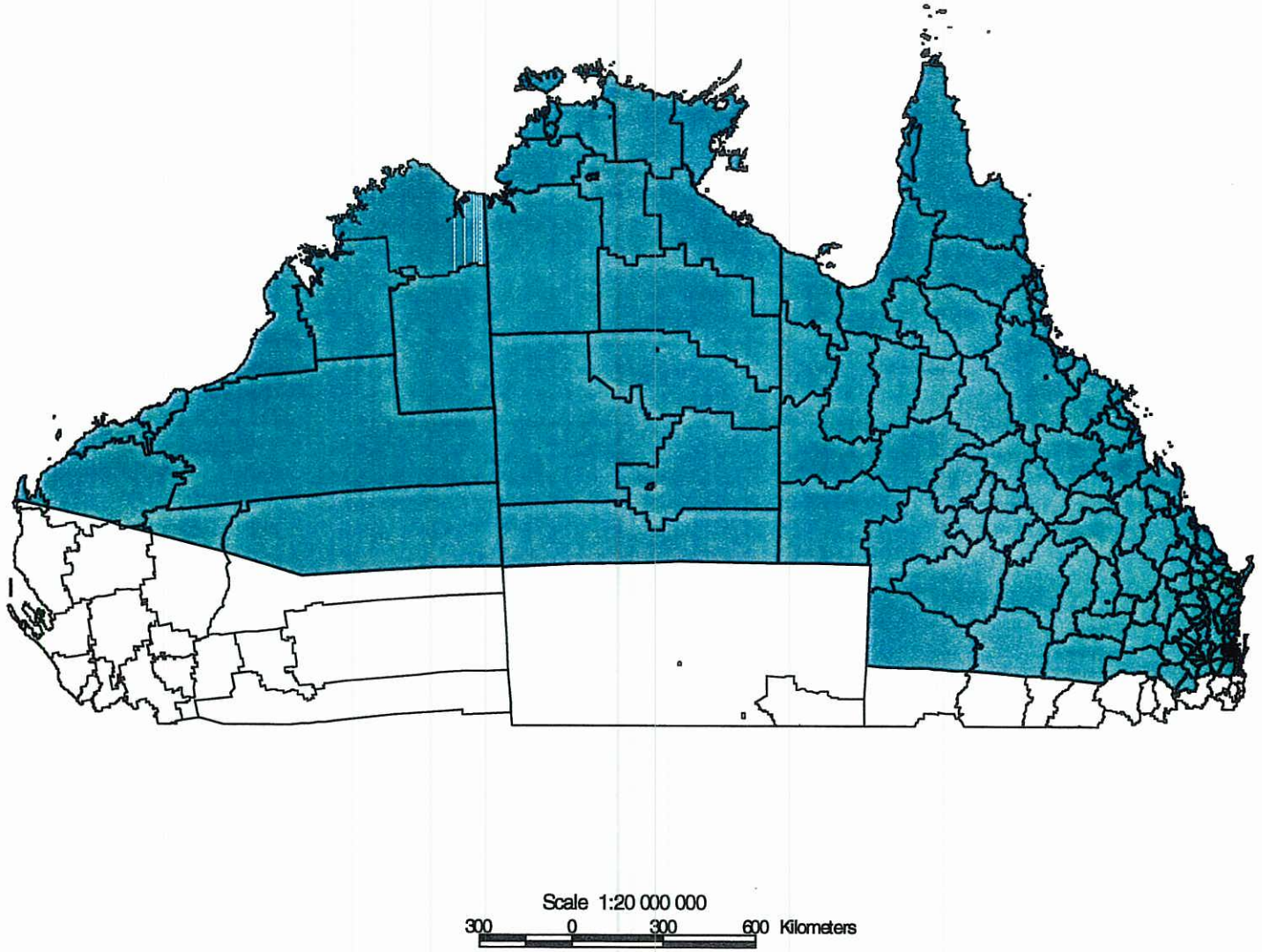


Figure 6.7. Land Tenure/Use in Northern Australia

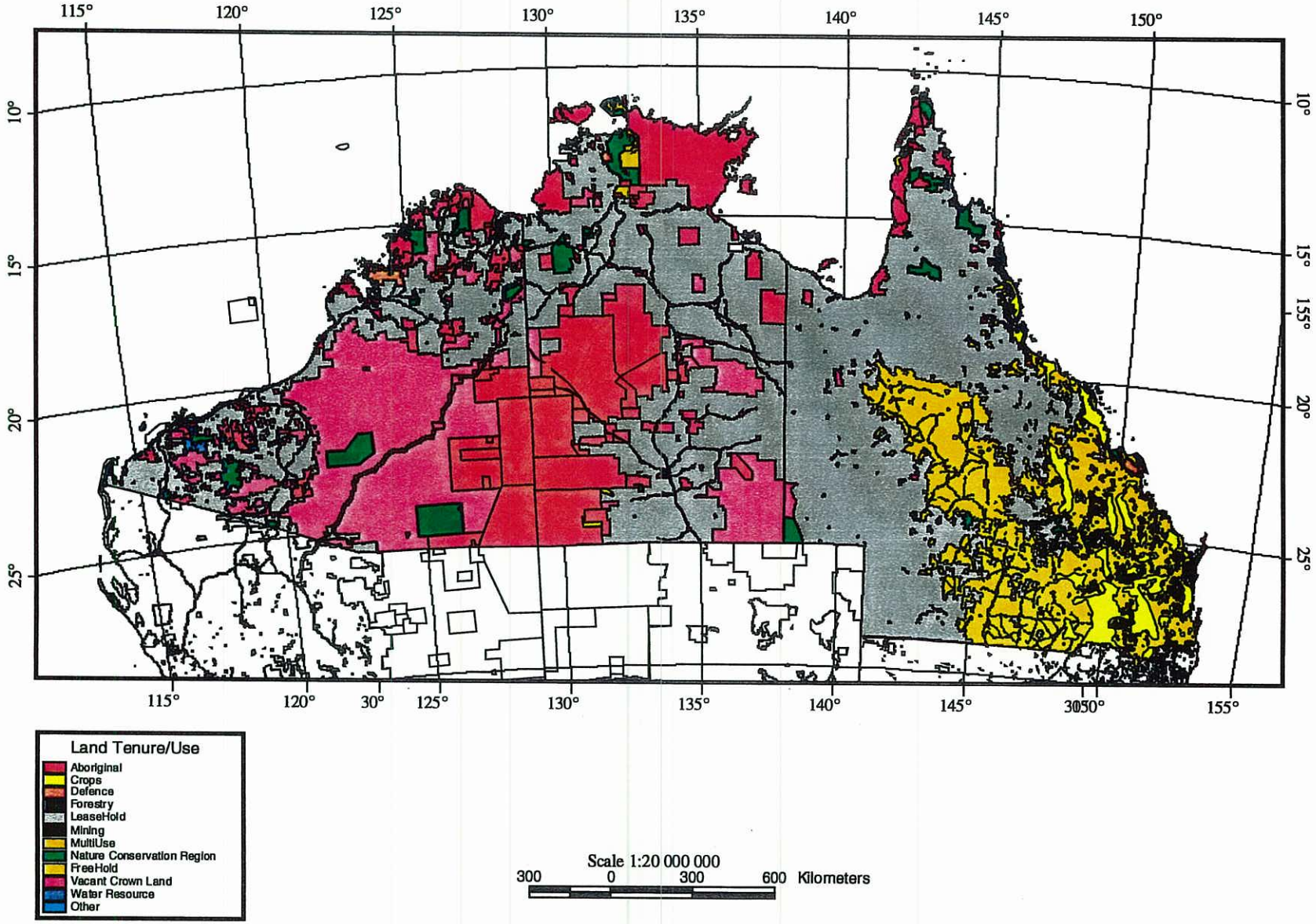


Figure 6.8. Grazing Land in Northern Australia

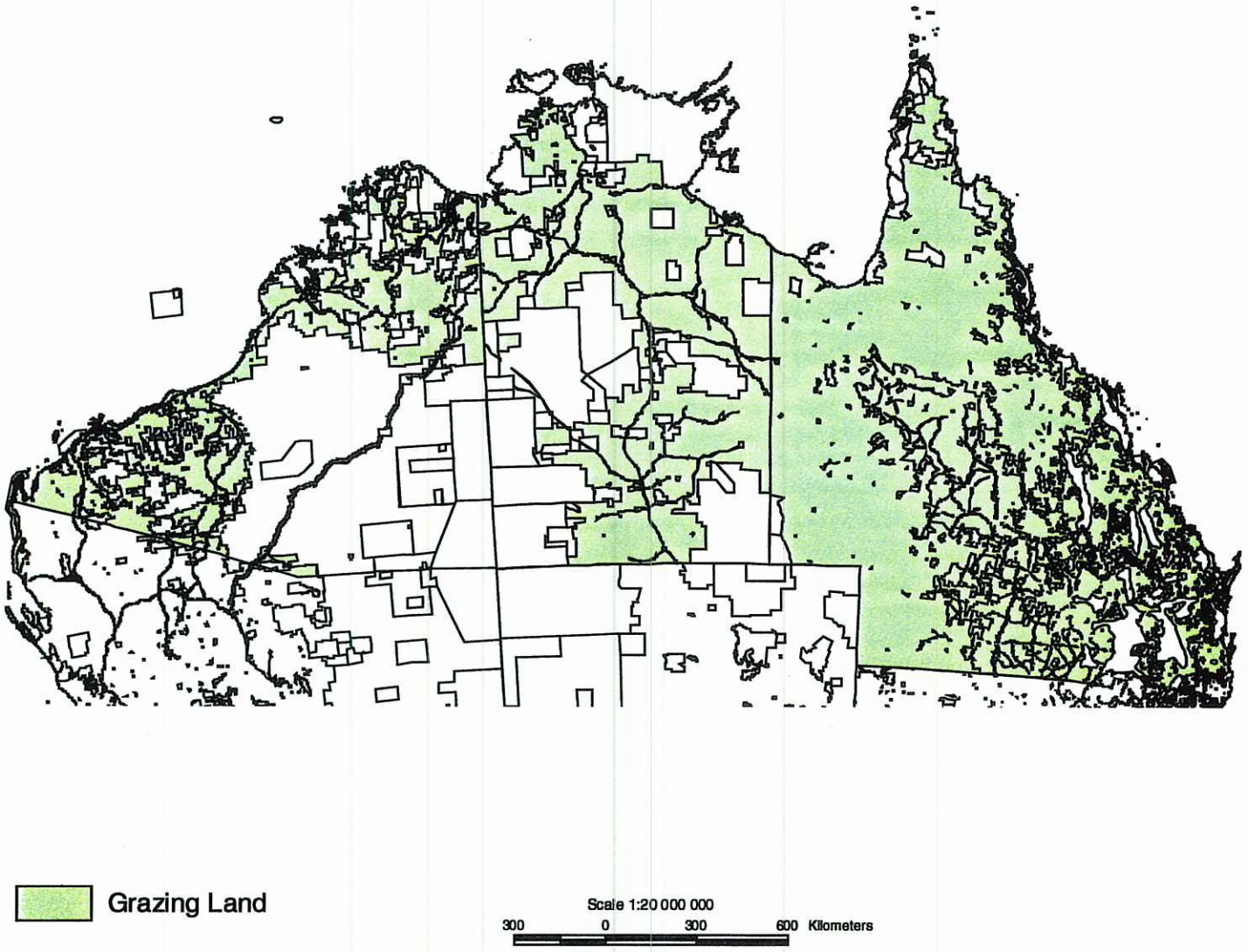


Figure 6.9. Relevance of Catchments to the Beef Industry - Northern Australia

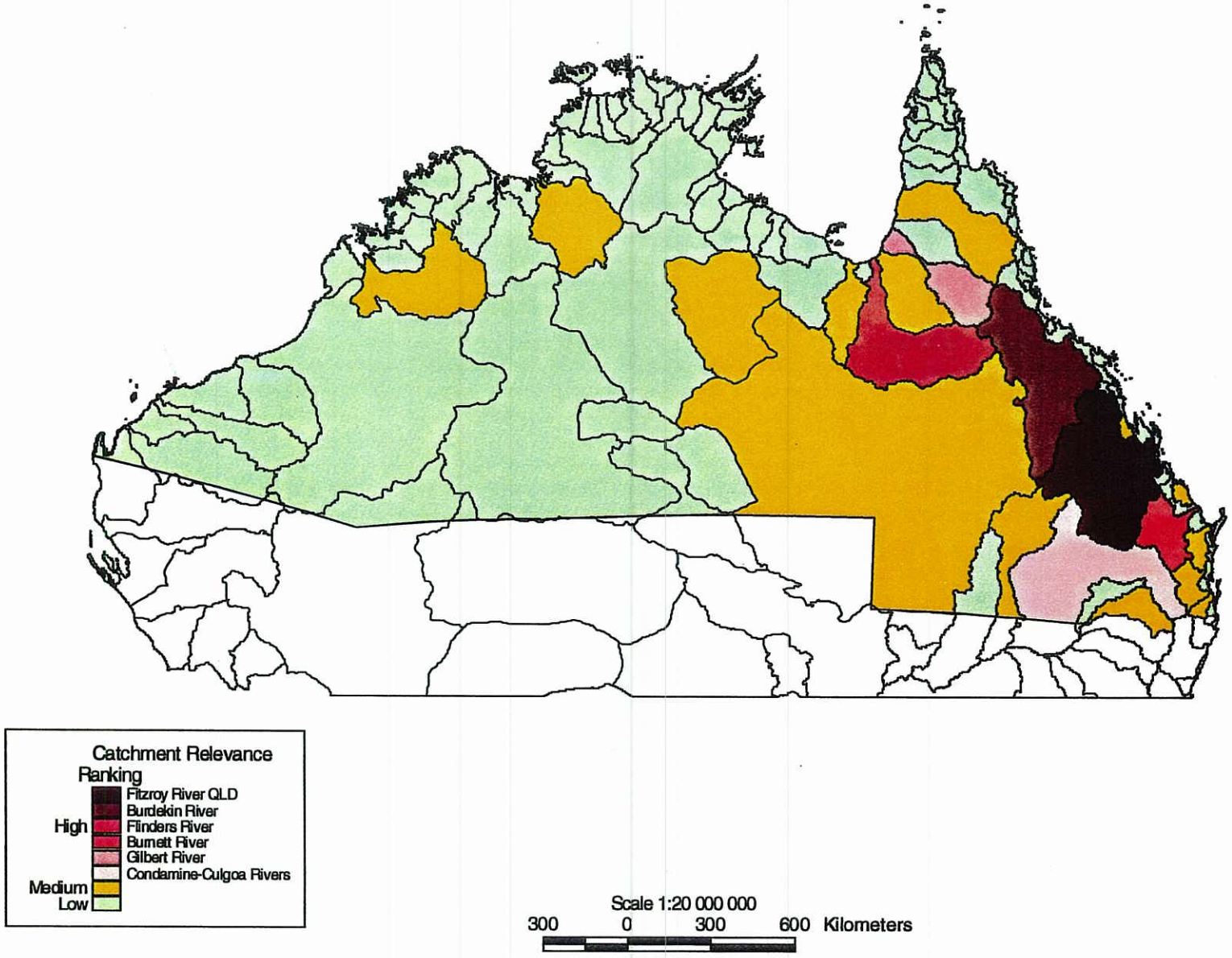


Figure 6.10: Catchments grouped by similarity of relevance to the beef industry - Northern Australia

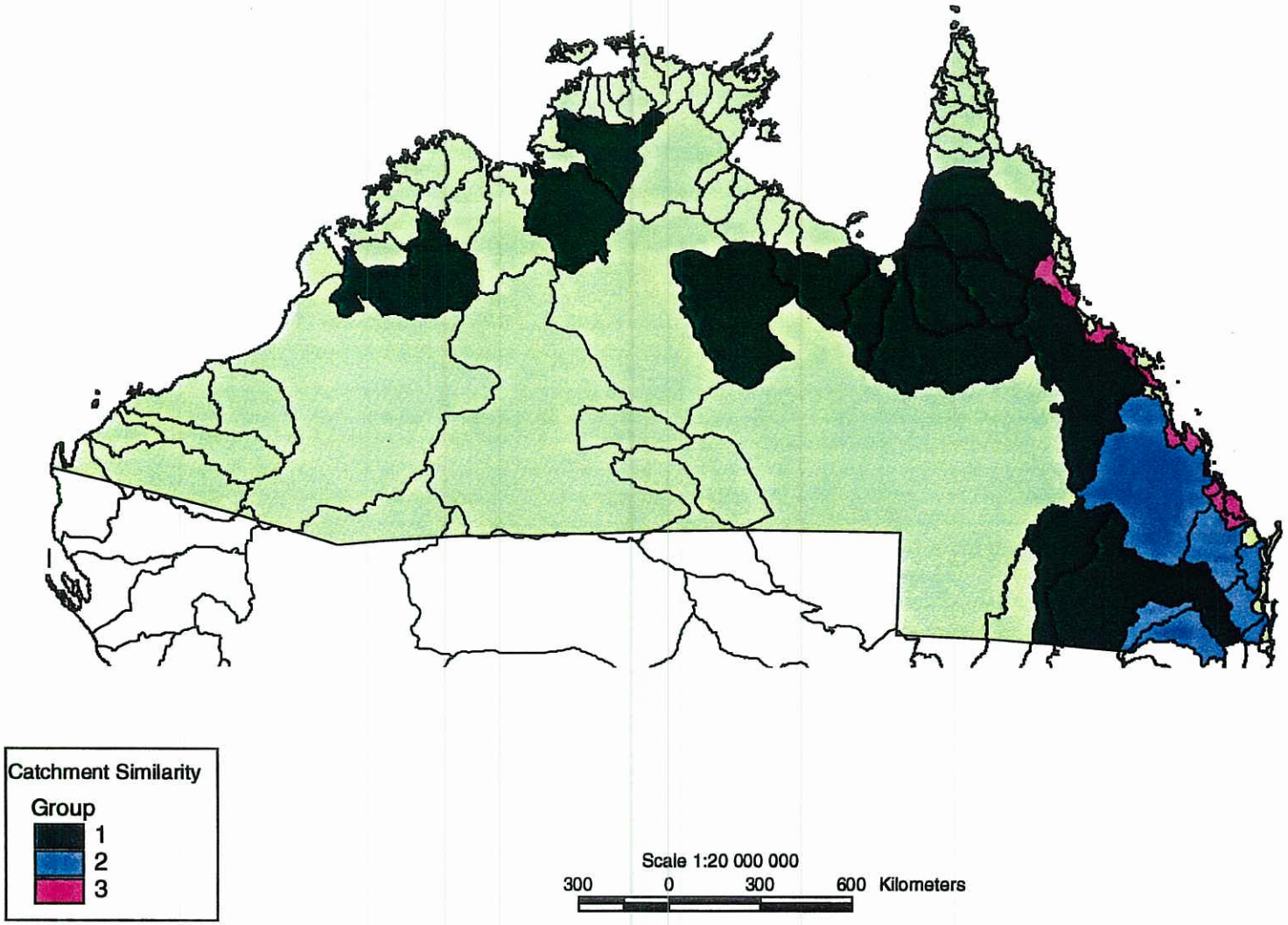
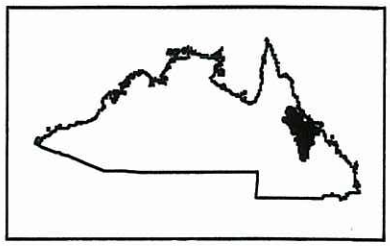
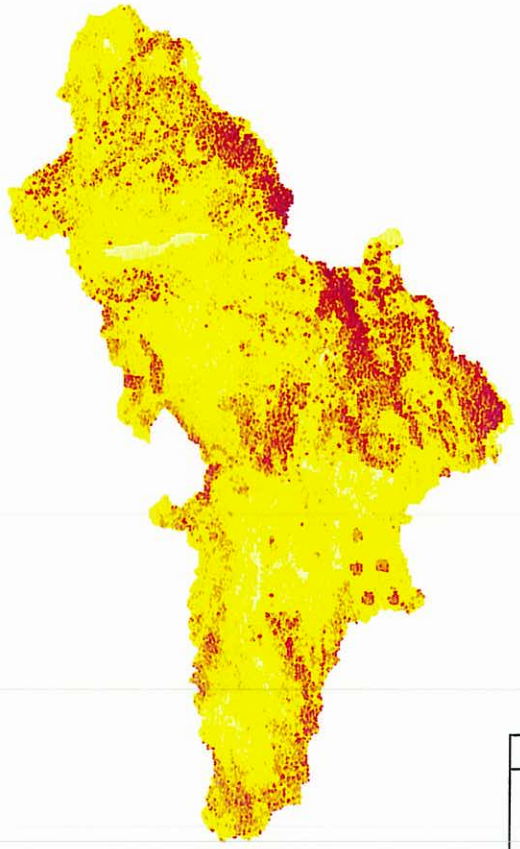


Figure 6.11: Burdekin River Catchment

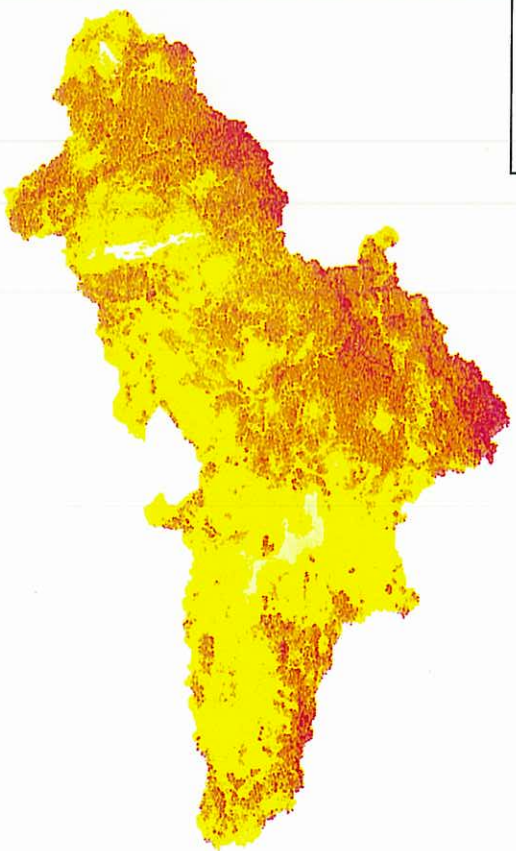




Sheet and Rill Erosion

- 0-0.25
- 0.25-0.5
- 0.5-1
- 1-3
- 3-5
- 5-7.5
- 7.5-10
- 10-25
- 25-50
- >50

Catchment Statistics	
Catchment Area (km^2)	129 860
Annual Discharge ($m^3 \times 10^6$)	8 770
Annual Runoff (mm)	68
Annual Average Rainfall (mm)	450-1500
Annual Rainfall Variability (CV%)	30-48
Seasonality of Rainfall (% AAR in Nov-Apr)	70-85
Cattle Number	1 116 880
Stocking Rate (animals/ha)	0.09
Grazed Land (% of Catchment)	95



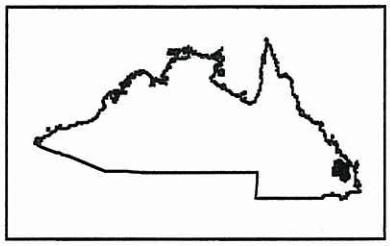
Gully and Channel Erosion

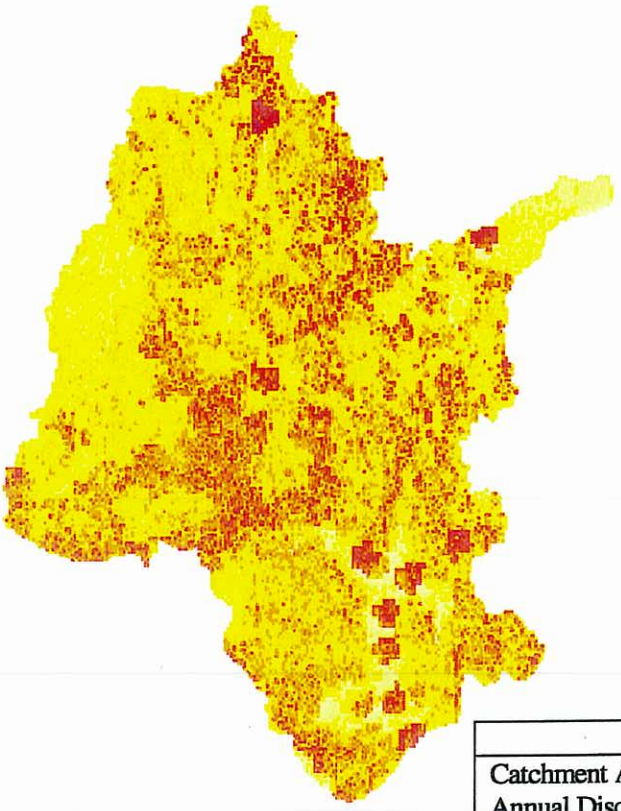
- 0-0.01
- 0.01-0.05
- 0.05-0.1
- 0.1-0.5
- 0.5-1
- 1-5
- 5-10
- 10-50
- 50-100
- >100

Scale 1:6 000 000

100 0 100 200 Kilometers

Figure 6.12: Burnett River Catchment

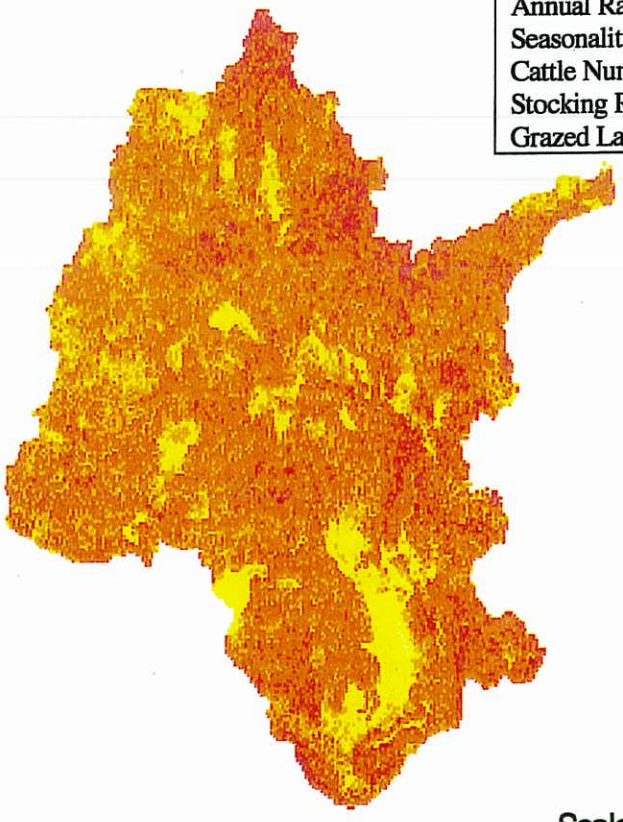




Sheet and Rill Erosion

- 0-0.25
- 0.25-0.5
- 0.5-1
- 1-3
- 3-5
- 5-7.5
- 7.5-10
- 10-25
- 25-50
- >50

Catchment Statistics	
Catchment Area (km^2)	33 150
Annual Discharge ($m^3 \times 10^6$)	1870
Annual Runoff (mm)	56
Annual Average Rainfall (mm)	750-1000
Annual Rainfall Variability (CV%)	25-35
Seasonality of Rainfall (% AAR in Nov-Apr)	65-70
Cattle Number	558 546
Stocking Rate (animals/ha)	0.23
Grazed Land (% of Catchment)	72



Gully and Channel Erosion

- 0-0.01
- 0.01-0.05
- 0.05-0.1
- 0.1-0.5
- 0.5-1
- 1-5
- 5-10
- 10-50
- 50-100
- >100

Scale 1:2 600 000

100 0 100 Kilometers