RANGELANDS
NRM Co-ordinating Group

A STRATEGY FOR MANAGING THE NATURAL RESOURCES OF WESTERN AUSTRALIA'S RANGELANDS

Australian Government

Government of Western Australia

Produced by the Rangelands NRM Co-ordinating Group 2005

A message from the Chair…

It is with great pleasure that I present this Natural Resource Management (NRM) Strategy for Western Australia's Rangelands.

It is the culmination of considerable effort by local communities, industry organisations and government to address a range of NRM issues in a Region stretching from the isolated Kimberley coast to the rugged Great Australian Bight – an area which is essentially one third of the entire continent, taking in the enormous and diverse sub-regions of the Kimberley, Pilbara, Gascoyne-Murchison and Goldfields-Nullarbor.

In this context I believe the Strategy is an enormously positive step forward for NRM in the Rangelands. It represents the aspirations of the Region's people for protecting valuable natural resources that:

- underpin a number of high value industries that contribute significantly to the State and, indeed the entire country's economic well being;
- make up much of Western Australia's unique and beautiful, natural environment; and
- ultimately sustain and add value to peoples' culture, ways of life and livelihoods.

Importantly, it provides the basis for investment in maintaining and enhancing the Region's natural resources through actions identified by people that use, manage and value them.

I would like to take this opportunity to thank people who have contributed to the Strategy from the tourism, fishing, pastoral, horticultural and mining industries, those involved in biodiversity conservation, Indigenous people, local government and the scientific community.

Whilst I am greatly appreciative of work done to date, I would like to point out that the Strategy is by no means an end point in relation to everything that is important for NRM in Western Australia's Rangelands. Rather it provides a foundation and framework for on-going community, industry and government input into NRM priority setting and resource allocation in the Region.

The Rangelands NRM Co-ordinating Group, which has overseen development of the Strategy, and which I chair, understands that priorities for NRM will change over time and that these will need to be reflected in the Strategy. To facilitate this, the Group will continue to work with people in the Kimberley, Pilbara, Gascoyne-Murchison and Goldfields-Nullarbor to provide opportunities for their input.

Thank you once again and we look forward to your on-going support.

Bill Mitchell
Chair
Rangelands NRM Co-ordinating Group Inc.

Acknowledgements

This Strategy was prepared by the Rangelands NRM Co-ordinating Group with considerable support from the State and Australian Government. The Group is greatly appreciative of this support and in particular would like to acknowledge the support provided by the:

- State Government Departments of:
    - Agriculture;
    - Conservation and Land Management;
    - Environment;
    - Fisheries;
    - Indigenous Affairs; and
    - Planning and Infrastructure; and the
- Australian Government Departments of:
    - Agriculture, Forestry and Fisheries; and
    - Environment and Heritage.

The Co-ordinating Group adopted a sub-regional approach to engaging with the community to develop the Strategy and so would also especially like to acknowledge the efforts of the:

- Kimberley NRM Group;
- Pilbara NRM Group;
- Gascoyne-Murchison NRM Council; and
- Goldfields-Nullarbor NRM Group.

These groups have coordinated engagement processes at the sub-regional level, which have provided opportunities for people to have input into the Strategy. The Co-ordinating Group acknowledges that it would not have been able to undertake this task on its own and therefore greatly appreciates the work that these groups have done to develop the Strategy to this point.

The Group acknowledges the past and present Indigenous custodians of the land within Western Australia's Rangelands, valuing their knowledge, and anticipating the contribution they can make to enhance our understanding and management of the Region's natural resources.

The Group also greatly appreciates the time and effort taken by individuals and peak organisations from the major interests and industries in the Region to contribute to the Strategy.

The Group would also like to acknowledge the efforts of its NRM Strategy Team, which has worked tirelessly to prepare the Strategy. The Group is greatly appreciative of their efforts.

Disclaimer: The information in this document is provided in good faith. The document is not policy of the Australian and Western Australian Government or the Rangeland NRM Co-ordinating Group. They do not accept responsibility for the accuracy or completeness of any material contained in this document.

Foreword

Introduction

This Natural Resource Management (NRM) Strategy focuses attention on Western Australia's "Rangelands NRM Region", and specifically on the use, management and value of the natural resources of its landscapes, waterscapes and seascapes.

It describes the natural resources that people believe are of greatest importance in the State's Rangelands and the ways in which they will work together to protect, maintain and where possible enhance them. People who have contributed to this Strategy are drawn from:

- local government;
- Indigenous land managers;
- people involved in conservation and biodiversity management;
- the pastoral, horticulture, tourism and mining industries;
- the aquaculture industry, and commercial and recreational fishing sectors;
- State and Australian Government agencies;
- the scientific community; and
- a range of other stakeholders with an interest in managing Western Australia's Rangelands.

Its development has been overseen by the Rangelands NRM Co-ordinating Group, and, whilst it outlines priorities, targets and actions for the whole of Western Australia's vast Rangelands NRM Region, it has been developed with specific input from the communities of the Kimberley, Pilbara, Gascoyne-Murchison and Goldfields-Nullarbor sub-regions. To this end the Co-ordinating Group has been supported by the interim:

- Kimberley NRM Group;
- Pilbara NRM Group;
- Gascoyne-Murchison NRM Council; and
- Goldfields-Nullarbor NRM Group.

Each of these sub-regional groups has overseen the specific tasks of community engagement to identify priority natural resource assets and develop targets for their long term protection, the results of which are outlined in the Strategy.

Strategy Format

The Rangelands NRM Strategy is based on an adaptive management or continuous improvement approach to resource management, similar to the "plan-do-check-review" model of environmental management systems (EMS). As such, it is part of an on-going learning process to manage the natural resources of the Region and consequently, will be the subject of regular review.

Adaptive management enables lessons learned to be realised and adjustments made in response. It utilises monitoring and evaluation activities to form a feedback loop to make these adjustments. Monitoring and evaluation activities will use many data sources, and complement one another, to cover the range of issues affecting performance and decision making. Regular collection of performance information will provide a basis for identifying needs and opportunities for evaluation and review. For instance, information from monitoring data can be a trigger for further action or investigation, and evaluation serves as a powerful tool for reviewing the appropriateness of performance indicators (NRM Ministerial Council, 2003).

The Strategy begins in **Section I** by broadly describing the way in which it has been developed and how people's input has been sought to develop it. It explains some of the inherent challenges associated with NRM planning in the Region and the Rangelands NRM Co-ordinating Group's on-going commitment

to tackling these. The first section also outlines people's aspirations for the Rangelands, highlighting their long term social, economic and environmental goals for the Region. In addition to the wider community's aspirations, it highlights the Rangelands NRM Co-ordinating Group's vision for the Region.

Section II goes on to broadly describe the current state of the Rangelands' landscapes, waterscapes and seascapes, the living and non-living assets contained within them, and the ways in which people use, manage and value these assets. It also describes the major threats to the assets and consequently why they need to be protected. Section II then goes on to highlight:

- the desired condition of the assets in about 20 years, reflected in a number of **resource condition targets (RCTs)**; and
- the actions that need to be undertaken to maintain, protect and enhance the assets during the next five years, reflected in a number of **management action targets (MATs)**.

Whilst Section II deals with the whole-of-the-Rangelands, **Section III** deals specifically with salinity and water quality issues in the Kimberley's Ord River catchment. Consequently, the priorities in this section are related to those of the National Action Plan for Salinity and Water Quality (NAP). Other NRM issues in the Ord, such as biodiversity management, which primarily address Natural Heritage Trust (NHT) priorities, are covered by Section II.

Having determined MATs for maintaining, protecting and enhancing the Region's natural resources, **Section IV** explains how these have been prioritised and therefore are possibilities for investment. Section IV however, does not document the NRM activities for funding through the NAP and NHT. This is the subject of a separate Investment Plan, which supports implementation of the Strategy.

Section IV also describes the Rangelands NRM Co-ordinating Group's commitment to establishing an appropriate monitoring and evaluation framework to assess progress of actions against targets outlined in the Strategy – or in other words the effectiveness of the investments being made in NRM in the Region. This component of the Strategy is imperative to support the adaptive management approach that the Strategy is based on.

Targets and Actions

As mentioned above, the Strategy sets out a number of MATs for NRM action throughout the Region, and these are grouped under five major categories:

1. Benchmarking and Monitoring;
2. On-ground Actions;
3. Institutional Frameworks, Planning and Policy;
4. Education, Awareness and Further Engagement ("capacity building"); and
5. Cultural Heritage.

In addition, the Strategy highlights the NRM issue they address, geographic focus of the targets and actions, potential partner organisations for implementation, their link to RCTs (and consequently their contribution to improving resource condition) and their priority.

Benchmarking and Monitoring

Benchmarking and monitoring are deficient in a number of NRM matters throughout the Rangelands, so a number of targets relate to the need to undertake this type of work. It has been acknowledged for some time that there are significant gaps in knowledge on the current state of some of the Region's natural resources.

On-ground Actions

On-ground action continues to be the primary mechanism for managing natural resources in the Rangelands. It is at this level that individuals, groups, organisations and the industries that actually use, manage and value the Region's natural resource can contribute to their sustainable use and protection.

Furthermore, the Rangelands NRM Co-ordinating Group believes that it is imperative that as many resources as possible "hit the ground" to support sustainable management to protect the social, economic and environmental values of the Region's natural resource assets.

Institutional Frameworks, Planning and Policy

MATs in this category present challenges for governments, particularly in developing more integrated approaches to NRM in the Rangelands.

A number of actions relate to the need to improve institutional arrangements and integrate policy and planning activities to allow more effective NRM in the Rangelands. It is felt that, in some areas, current arrangements actually provide barriers to effective NRM. The sometimes disintegrated nature of government service delivery can make it difficult for users and managers to implement sustainable practices.

A particular issue for Western Australia's Rangelands is the need to establish institutional arrangements and planning processes that accommodate multiple uses, management regimes and values. This is particularly evident in arrangements for land tenure, which currently, can for example, present barriers to developing alternative industries on pastoral land. The State Government is currently looking into addressing some of these barriers through its review of the pastoral industry and use of rangeland resources.

Education, Awareness and Further Engagement ("capacity building")

There is a relatively low level of awareness amongst Rangelands stakeholders of the Regional NRM planning and delivery process. Whilst some stakeholder groups have been reasonably well engaged in NRM in the past, there are others where more effort is required. Consequently, a number of targets in the Strategy relate to the need to build capacity among stakeholders in the Region. There is also a need to better engage those stakeholders "outside" the Region that have interests in NRM in the Rangelands.

Improved capacity building and stakeholder engagement are vital for implementation of the Rangelands NRM Strategy. This encompasses four main categories of action, all of which are considered critical in contributing to effective NRM outcomes in the Rangelands:

- **Awareness**: ensuring that communities are aware of issues that are affecting the sustainability of natural resources, of the need for actions and of the importance of their own participation.
- **Information**: ensuring that communities have the appropriate information to make informed decisions about actions that need to be taken.
- **Skills**: ensuring that communities have the appropriate skills to be able to take effective action.
- **Facilitation and Support**: ensuring that there are mechanisms, people and other resources to help communities (to put their knowledge, skills and commitment into effect) achieve desired NRM outcomes.

Cultural Heritage

The Rangelands has special cultural and heritage significance for its people, particularly in relation to their connection to natural resources. The Region contains many places of cultural and spiritual significance for Aboriginal people who have inhabited it for tens of thousands of years, and it is of great historical importance to people involved in industries such as pastoralism, mining and fishing. Furthermore, many people have considerable local knowledge in relation to NRM that needs to be incorporated into the Regional planning process.

A number of targets in the Strategy highlight the need to protect areas of significance and resources important to people for cultural and heritage reasons. Targets have also been developed that reflect the need to capture local knowledge to improve the broader community's understanding of NRM.

Investment Planning

Ultimately the Rangelands NRM Strategy is being developed to guide NRM investment in the Region, and to support the people who use, manage and value its natural resources to implement sustainable actions. To implement these actions, an Investment Plan has been developed which outline priorities, partner organisations, funding arrangements, actions and mechanisms to assess the progress of these actions.

The Investment Plan is essential for NHT and NAP funds to flow to the Region and the Rangelands NRM Co-ordinating Group will continue to work with the sub-regions and consult key stakeholders about investment priorities. This will require careful consideration of social, economic and environmental issues and determining the "trade-offs" that need to be made to achieve multiple NRM outcomes.

The Future

As previously mentioned the Rangelands Strategy is part of an adaptive management process to improve NRM in the Region. This Strategy is a "snapshot" in time of current priorities and actions.

Whilst the Rangelands NRM Co-ordinating Group is pleased to have developed the Strategy to this point it is certainly not presenting it as the "final word" on NRM for the Region. It believes it has essentially made a start with the Regional NRM planning and delivery model agreed by the Australian and State Governments, and that the Strategy and subsequent Investment Plan represent this start. The Group accepts that there is considerably more work to be done in a number of areas, particularly in:

- more widely engaging with the Region's stakeholders;
- setting more credible resource condition and management action targets; and
- establishing more broadly agreed priorities for NRM investment.

These three areas will be the main foci for the on-going work of the Group. In support of this long term approach, the Strategy will be reviewed within two years of accreditation and the Investment Plan will be reviewed annually.

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Appendices **(provided in a separate document)**

SECTION I - THE RANGELANDS

1.1 Western Australia's Rangelands NRM Region

More than 75 percent of Australia is generally described as "Rangelands", encompassing a very diverse group of relatively undisturbed ecosystems, including tropical savannas, woodlands, shrublands and grqasslands. These ecosystems support a number of industries such as tourism, mining and pastoral production. They are also important for biodiversity conservation, lifestyle, a rich social and cultural heritage, clean air and water, food and carbon storage (NLWRA, 2001).

Western Australia's "Rangelands Natural Resource Management (NRM) Region" accounts for almost 90 percent of the State's land mass and includes more than 75 percent of its coastline. It has a relatively low population, with numbers generally declining throughout the Region (Environmental Protection Authority, 2004, p 3), with the exception of the Kimberley. This small population is distributed throughout four sub-regions (Figure 1), which are very large areas in their own right. They can be generally defined on social, economic and biophysical grounds as the:

- Kimberley, which is approximately 425,000 square kilometres with a population of about 40,600;
- Pilbara, which is approximately 500,000 square kilometres with a population of about 39,500;
- Gascoyne-Murchison, which is approximately 480,000 square kilometres with a population of about 20,000; and
- Goldfields-Nullarbor, which is approximately 930,000 square kilometres and includes Western Australia's inland desert country, and has a population of about 44,000.

Characteristics of the Sub-regions

The sub-regions are home to a diverse range of communities and cultures, resource uses, tenure and management regimes, and physical environments including:

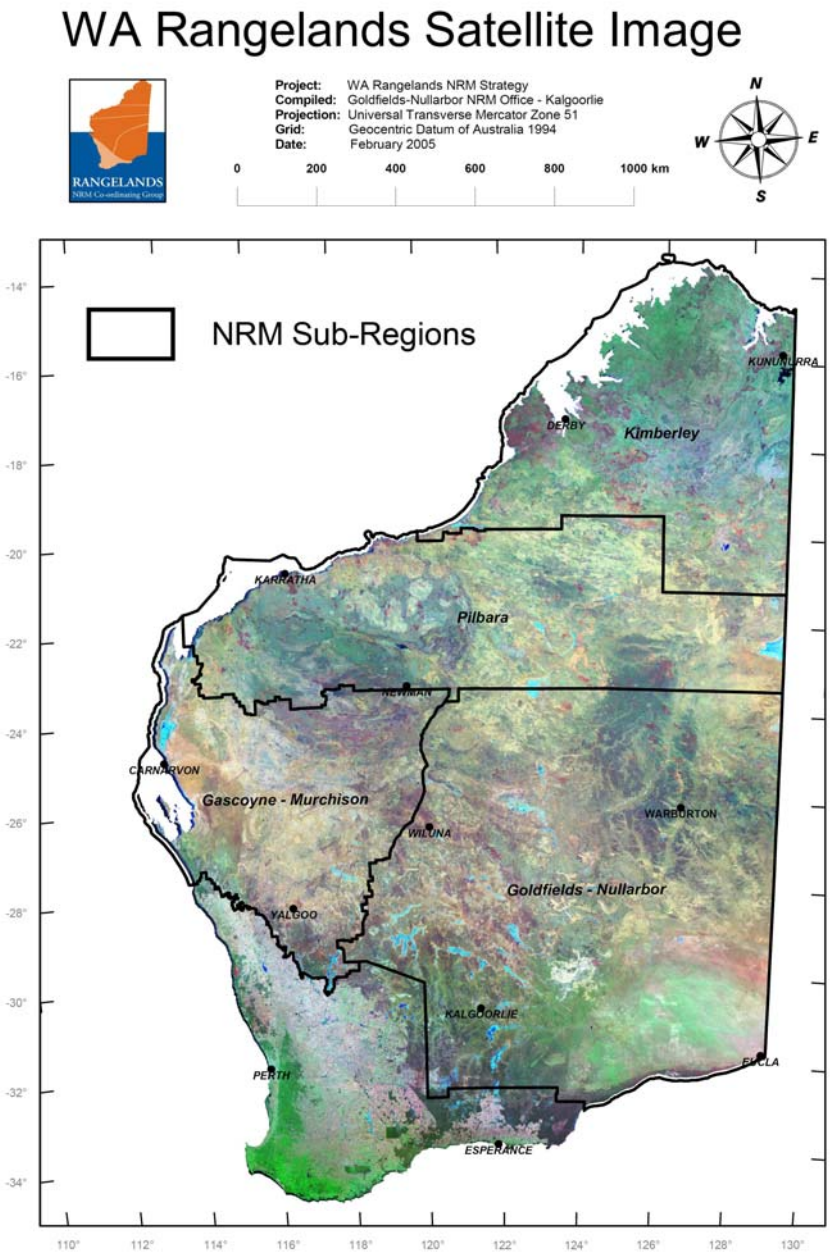
- the State's pastoral areas covering approximately 30 percent of the Region at 98 million hectares;
- a large conservation estate of National Parks, Nature Reserves, Conservation Parks, Marine Parks and Reserves and World Heritage listed areas at Shark Bay and Purnululu National Park. Four of the 15 National Biodiversity Hotspots occur in Western Australia's Rangelands and the Prince Regent Nature Reserve is one of the State's two Biospheres;
- some of the State's, (and indeed the country's) natural icons, such as the Ningaloo Marine Park, Mount Augustus, Mitchell Plateau, Nullarbor Plain, and Karijini National Park;
- wetlands of International Importance (Ramsar sites) and nationally important wetlands. The Rangelands contains four Ramsar sites and 57 nationally important wetlands;
- the world's largest semi-arid karst system, with significant karst areas on the Nullarbor, and at Cape Range and the West Kimberley Limestone Ranges;
- large tracts of Unallocated Crown Land (UCL) and Unmanaged Reserves (UMR);
- cultural landscapes;
- areas of high natural values, known to many as wilderness; and
- significant water resources including valuable groundwater aquifers that support unique ecosystems and expansive industries, estuaries and major river systems including some of the State's last "Wild Rivers".

It is also an area of great natural, economic, social and cultural significance containing:

- substantial amounts of the State's biological diversity, including many threatened species of flora, fauna and threatened ecological communities;
- many areas of cultural and spiritual importance for Aboriginal people;

- communities of people who have a close affinity with their lands;
- most of the State's (and a significant amount of the entire country's) mineral and petroleum products;
- valuable beef, wool, sheep, fishing and aquaculture industries;
- major tourist destinations with many new emerging tourism opportunities; and
- established horticultural industries as well as emerging opportunities for enterprises such as inland horticulture and arid land plantation forestry.

Figure 1: The Rangelands NRM Region and Sub-regions



Challenges for NRM in the Rangelands

Whilst the Region is home to great diversity and wealth, its natural resources and people face a number of challenges related to resource management. These include managing multiple resource uses, managing pastoral production with significant climatic variability, increasing tourism pressure (particularly on sensitive coastal and marine, and riverine areas), altered and inappropriate fire regimes, plant and animal pests, declining native vegetation in some parts of the landscape and changes to vegetation structure, changes in water regimes and air quality. These and many other issues are causing significant land and water degradation, biodiversity loss and reduction in productivity (Environmental Protection Authority, 2004).

However, whilst unsustainable use and management have degraded large areas of the Region, the Rangelands are still largely "intact". Therefore a challenge for NRM is to build on the opportunities that this provides and implement sustainable systems that accommodate multiple outcomes for the Region's people and its natural resources (Environmental Protection Authority, 2004).

A more comprehensive description of the sub-regions and the NRM issues and challenges that face them is included at Appendix I. The Environmental Protection Authority's Position Statement Number Five (2004), *Environmental Protection and Ecological Sustainability of the Rangelands in Western Australia,* also provides a summary of the environmental pressures and challenges being experienced in the Region.

1.2 Rangelands NRM Strategy

This Strategy begins to address the challenges refered to above (and others), by looking critically at three key questions:

- what natural resources are important but are under threat or provide opportunities, and therefore should be maintained, protected or enhanced;
- what condition should these natural resources be in, in the future; and
- what areas of activity should be invested in so that they are in this condition in the future?

Or in other words:

- what are the **priority natural resource assets** of the Region;
- what are the **resource condition targets** (RCTs) for the Region; and
- what are the **management action targets** (MATs) for the Region?

These are the three core elements of the Regional NRM planning and delivery process, which provide the basis for NRM investment in the Rangelands. The process is largely being facilitated by two national programs - the extension of the Natural Heritage Trust (NHT) and the National Action Plan for Salinity and Water Quality (NAP).

These elements have been developed using a range of community engagement processes in the sub-regions, described in detail at Appendix III.

1.3 Rangelands NRM Arrangements

The Rangelands NRM Region is one of 56 throughout the country where the Regional NRM planning and delivery process is being implemented. The body overseeing the process for the Rangelands, the Rangelands NRM Co-ordinating Group, has representatives from community and industry groups involved in managing the Region's natural resources as well as the State and Australian Governments. A more detailed description of the Group can be found at Appendix II.

In developing the Strategy, the Group has sought input from communities, industry organisations and government bodies in the Kimberley, Pilbara, Gascoyne-Murchison and Goldfields-Nullarbor. It has invited them to establish their own arrangements to identify priority assets and set targets for input into the Rangelands Strategy. Given its size, and the diversity of issues and interests throughout the Region, this approach has ensured that a broad range of stakeholders have had input into the Strategy, which may not have been possible using a more centralised planning approach.

The Extension of NHT

Whilst the Strategy (and its Investment Plan) can support investment in NRM actions through a range of sources, it primarily targets investment through the extension of NHT in accordance with the Trust's three overarching objectives:

- **Biodiversity conservation** - the conservation of Australia's biodiversity through the protection and restoration of terrestrial, freshwater, estuarine and marine ecosystems and habitat for native plants and animals;
- **Sustainable use of natural resources** - the sustainable use and management of Australia's land, water and marine resources to maintain and improve the productivity and profitability of resource based industries; and
- **Community capacity building and institutional change** - support for individuals, landholders, industry and communities with skills, knowledge, information and institutional frameworks to promote biodiversity conservation and sustainable resource use and management.

Furthermore, investment will target the 10 areas of Trust activity, which define its scope. They are:

1. Protecting and restoring the habitat of threatened species, threatened ecological communities and migratory birds;
2. Reversing the long-term decline in the extent and quality of Australia's native vegetation;
3. Protecting and restoring significant freshwater, marine and estuarine ecosystems;
4. Preventing or controlling the introduction and spread of feral animals, aquatic pests, weeds and other biological threats to biodiversity;
5. Establishing and effectively managing a comprehensive, adequate and representative system of protected areas;
6. Improving the condition of natural resources that underpins the sustainability and productivity of resource based industries;
7. Securing access to natural resources for productive purposes;
8. Encouraging the development of sustainable and profitable management systems for application by land-holders and other natural resource managers and users;
9. Providing land-holders, community groups and other natural resource managers with understanding and skills to contribute to biodiversity conservation and sustainable natural resource management; and
10. Establishing institutional and organisational frameworks that promote conservation and ecologically sustainable use and management of natural resources.

The National Action Plan

The other major, national program to be delivered in the Rangelands is the NAP, which is also focused on regional planning and delivery, but addresses issues of salinity and water quality. There are 21 priority NAP Regions throughout Australia.

The goal of the NAP is to motivate and enable Regional communities to use coordinated and targeted action to:

- prevent, stabilise and reverse trends in salinity, particularly dryland salinity, affecting the sustainability of production, the conservation of biological diversity and the viability of our infrastructure; and
- improve water quality and secure reliable allocations for human uses, industry and the environment (Australian Government Departments of Agriculture, Fisheries and Forestry, and Environment and Heritage, 2000, p. 5).

It builds on NHT investment and initiatives of the State Government and the Murray Darling Basin Ministerial Council to integrate approaches to improve the management of salinity and water quality. In particular it:

- provides the basis for a national approach to salinity and water quality solutions by engaging the Commonwealth, States/ Territories and community;
- provides a total package with funding accompanied by State action to establish property rights and protect environmental quality;
- requires accountability for the use of public funds through accreditation of plans and stringent requirements for monitoring, reporting and decision making; and
- shifts the focus to proactive outcome driven community plans with performance monitoring and supported by a better regulatory environment, the application of scientific knowledge and expertise for community benefit and more efficient use of limited funds (Australian Government Departments of Agriculture, Fisheries and Forestry, and Environment and Heritage, 2000, p. 11).

The Ord NAP Region

The Rangelands contains one priority NAP Region; the Ord River catchment in the Kimberley. NRM issues for the Ord are dealt with separately in Section III of the Strategy as they relate primarily to the NAP and target NAP funding.

The inclusion of Ord NAP issues in the Strategy has been overseen by the Ord Catchment Reference Group and Interim Kimberley NRM Group and builds on the work of Ord Land and Water, which developed the *Ord Land and Water Management Plan 2000*. A project to extend the consultation process and commence some of the actions in the plan is a high priority in the Region.

Ord Land and Water maintains linkages and communication with other Rangeland users and managers, who can have impacts in the irrigation area. Furthermore, an interagency technical working group is working to integrate planning and management, and recognise environmental, cultural and social values.

1.4 How the Community was Engaged to Develop the Strategy

To develop the Strategy, the Rangelands NRM Co-ordinating Group engaged with people in the Rangelands' sub-regions and sought their input on what is important to them for NRM. Community engagement processes used in each sub-region have evolved somewhat differently, but have been, and will continue to be, consistent with the Protocol for Community Engagement of the Bilateral Agreements to deliver the extension of NHT and NAP. Every effort is being made to meet the Protocol's requirement to include:

- local government; State and Commonwealth agencies; Indigenous communities; key industry, environmental and community development groups; relevant NRM community groups; the relevant academic/ scientific community, as well as the general public and individuals with an interest in NRM in the Region.

The ways in which these stakeholders have been engaged is detailed in a Community Engagement Protocol at Appendix III.

Despite the Co-ordinating Group's best efforts to consult widely with people throughout the State, it concedes there is still far more work to do in this area. As a consequence of particular constraints,

namely lack of time and the sheer size of the Region, it has not been possible to achieve the level of engagement that it would have considered ideal. This became particularly evident during the formal community consultation period, where most stakeholder groups expressed some level of dissatisfaction at the amount of time available to provide input into the Strategy.

However, as previously mentioned this Strategy is a starting point. The Group understands who its major stakeholders are and that it needs to continue to provide opportunities for them to be involved. It is commited to providing these opportunities for the range of major stakeholder groups listed below as well as many others.

Local Government

In the Rangelands there are:

- four local government authorities in the Kimberley;
- four in the Pilbara;
- nine whole and six part local government authorities in the Gascoyne-Murchison; and
- nine authorities in the Goldfields-Nullarbor.

Local government is considered to be an important stakeholder in NRM planning. Local government authorities are being engaged specifically within the sub-regions at an institutional level with local council members represented on sub-regional NRM groups. The Rangelands NRM Co-ordinating Group is committed to increasing engagement with local councils throughout the Region and working directly with local government NRM facilitators.

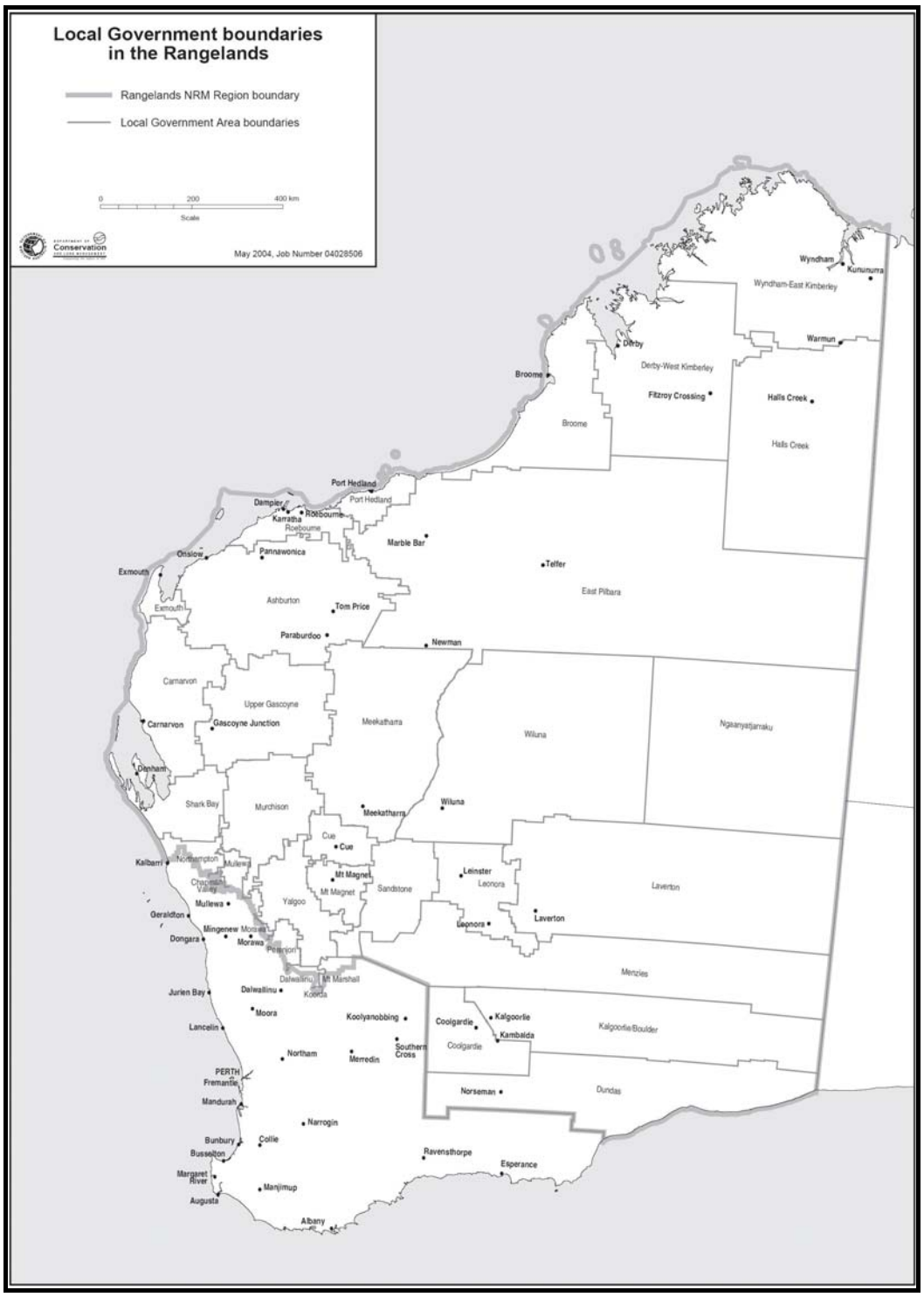


Figure 2: Local Government Boundaries in the Rangelands

State Government

There are a number of key State Government agencies involved in, and supporting the NRM planning process in the Rangelands. These agencies are represented on the Rangelands NRM Co-ordinating Group, its Technical Working Group and sub-regional NRM groups. They include the Departments of:

- Conservation and Land Management (lead State NRM agency for the Rangelands);
- Environment;
- Agriculture;
- Planning and Infrastructure;
- Indigenous Affairs;
- Fisheries; and
- the Development Commissions located in the Region.

As well as being sources of technical information for the Strategy, the agencies are taking a prominent role in supporting community engagement processes in the Rangelands. State agencies also host a number of NRM strategist and coordinator positions, further facilitating community engagement.

State agencies also provide input on the State Government's priorities and targets for NRM in the Region.

Indigenous Stakeholders

Aboriginal peoples are a major stakeholder group thoughout the Region, that for many years have been striving for recognition as owners and custodians of country. Aboriginal people control almost 20 percent of the Rangelands through the Aboriginal Lands Trust (ALT), Indigenous pastoral properties, Aboriginal reserves and homelands through Native Title determinations.

European settlement has caused dispossession, disease and serious detrimental impacts on Aboriginal cultural and kinship systems. However, there is growing legal recognition of Traditional rights and obligations through western legal frameworks and policy changes, and in response government is developing strategies to address these issues. The challenge is to deliver these strategies in a way that is consistent with the concerns of Aboriginal people, including through appropriate consultation. The Department of Indigenous Affairs, as the responsible agency for Indigenous matters, and the ALT, as the major landholder on behalf of Aboriginal communities, are working on strategies for Aboriginal engagement in managing land and water in the Rangelands.

Aboriginal peoples' influence is not restricted to lands in their title, as all of the Rangelands are known and valued by them. Therefore the Strategy, and its on-going engagement processes, must provide for Aboriginal participation in all matters related to NRM.

Engagement with Indigenous land managers is developing within each sub-region. Indigenous representatives sit on sub-regional NRM groups throughout the Region, and an Indigenous representative sits on the Rangelands NRM Co-ordinating Group. There have been workshops in particular sub-regions focused on engaging Indigenous stakeholders, particularly in the Kimberley and Pilbara. Additionally, there are Indigenous NRM facilitators employed in the Rangelands to assist with this work. In the Kimberley, the Healthy Country project provided a basis for the development of an Aboriginal Reference Group to participate in NRM. Following on from the Healthy Country project a workshop was held in Bungarun to identify assets, threats and actions, with over 300 participants (See Appendix III). Nonetheless, there is still more to do and Aboriginal people are keen to see appropriate NRM actions developed into on-ground projects.

Aboriginal people face many on-going challenges as individuals and communities. The last three decades have focused on health, education and employment but there is a shift in acknowledging other

facets of Aboriginal lifestyle, which NRM processes can contribute to. NRM has great potential benefit in these areas because of it can help to restore relationships of people to land and waters through recognition of traditional ecological knowledge as well as providing economic and educational opportunities. This in turn creates a sense of pride and well being within individuals and communities. Opportunities for Indigenous involvement in NRM could include capturing cultural values, increasing and building on biodiversity knowledge, bush tucker tours and seed collection. Aboriginal people also place a great importance on ownership of land and there is a desire to have a greater share in the ownership of parts of the Rangelands.

Aboriginal consultation is acknowledged by the Co-ordinating Group and sub-regional NRM groups as a priority for on-going community engagement throughout the Rangelands.

Pastoral Land Managers

Pastoralism is the most geographically significant industry in the Rangelands, with approximately 481 pastoral stations throughout the Region. As a result, pastoralists are a key stakeholder group for engagement. The Co-ordinating Group will conitinue consultation with the industry at sub-regional level and via peak industry bodies, the Pastoralists and Graziers Association (PGA) and Western Australian Farmers Federation (WAFF).

Within each sub-region, pastoralists have been consulted through groups such as land conservation district committees (LCDCs), local zone meetings of the PGA and Zone Control Authorities (ZCAs), and by representation on sub-regional NRM groups.

Given the area managed for pastoral purposes in the Region, pastoralists are a key stakeholder group because they collectively have direct land management responsibility for large tracts of the Rangelands. Furthermore pastoral land managers have made significant contributions in the past to rangeland management through improving rangeland condition and protecting the Region's biodiversity. The Rangelands NRM Co-ordinating Group is commited to continue working with the pastoral industry on initiatives that will see the achievement of these dual objectives of sustainable land management and protection of biodiversity.

Conservation and Biodiversity

A range of community groups involved in conservation and biodiversity in the Rangelands are being consulted at sub-regional and Regional levels. They range from local scale environment groups, such as the Community Consultative Committee for the Shark Bay World Heritage Area, to larger organisations such as World Wildlife Fund (WWF) and the Conservation Council of Western Australia.

Additionally, representatives from environmental groups are key members of some sub-regional groups. For example, Environs Kimberley and SEEKS (Save Endangered East Kimberley Species) are represented on the Interim Kimberley NRM Group.

There are a number of other groups with an interest in Rangelands conservation and biodiversity that the Co-ordinating Group is keen to engage with in the future, such as groups with an interest in speleology.

Fishing and Aquaculture Industries

This stakeholder group comprises the commercial, aquaculture and recreational fishing sectors. These sectors are being engaged as an important, relatively new stakeholder group, given the requirement to address coastal and marine issues in the Strategy.

The commercial fishing sector has been engaged at peak body level through the Western Australian Fishing Industry Council (WAFIC). The aquaculture sector has been engaged through its two peak bodies, the Aquaculture Council of Western Australia (ACWA) and the Pearl Producers Association (PPA). The recreational fishing sector has been consulted through RecFish West and the Regional

Recreational Fishing Advisory Council (RRFAC). Fishing and aquaculture industry representatives also sit on sub-regional NRM groups and various reference and focus groups.

Minerals and Petroleum Industry

The mining and petroleum industry is a particularly important stakeholder in the Rangelands, which contributes significantly to the State and national economies. It impacts on only small areas of land, yet contributes very significantly to local economies. The industry has significant expertise and other capacities that can support NRM in the Rangelands. It contributes to NRM in the Region through innovation in environmental practices, community funding and support and contribution to ecological knowledge. To this end the Rangelands NRM Co-ordinating Group is keen to work with the industry where appropriate.

A mining industry representative sits on the Rangelands NRM Co-ordinating Group and sub-regional groups have representatives from mining companies. In addition, some sub-regions have been liaising with the Chamber of Minerals and Energy to determine the most appropriate ways to engage the mining and petroleum industry on NRM.

Tourism

Tourism is an important industry throughout the Rangelands, which largely relies on the unaltered natural attractions of the Region. Its impact has significant implications for NRM, particularly for sensitive coastal and marine areas, and waterways. Sub-regional NRM groups are engaging with individual tourism operators and associations as well as with the State's peak body, Tourism Western Australia.

There are many opportunities for the tourism industry to contribute to NRM outcomes in the Rangelands such as managing visitor impacts at environmentally sensitve areas and conserving sensitive areas valuable to the industry.

Horticulture

Horticulture occurs on a large scale on the floodplains of the Gascoyne and Ord Rivers and at smaller scales in other locations throughout the Region. Large scale operations occur at the Kimberley's Ord River Irrigation Area, and at Carnarvon in the Gascoyne-Murchison. Consequently, the horticulture industry has been targeted as a key stakeholder group in these sub-regions. In both sub-regions, peak horticulture industry body representatives are involved with sub-regional groups. Specific workshops have also taken place in these sub-regions to address NRM issues related to horticulture such as water extraction, soil conservation and biosecurity.

1.5 How Assets Were Identified

As can be seen, a number of stakeholder groups have been engaged to identify the Region's priority natural resource assets. There has been some variation in the general approaches taken to asset identification in the sub-regions; however, each sub-regional group has remained focused on the three core elements of the regional planning process in determining priority assets, RCTs and MATs.

The Interim Kimberley NRM Group worked with communities in the sub-region to identify assets in the theme areas of social, environmental, economic and cultural. The Group believed that breaking assets and threats into themes provided the opportunity for greater discussion and enabled stakeholders to look outside their areas of direct interest. To tease out the key assets and threats in each area, the Interim Kimberley NRM Group focused on the questions of:

- What do we want to protect?
- What threatens what we want to protect?
- What actions can we take to protect assets against threatening processes?

The Interim Pilbara NRM Group adopted a similar approach, focusing community discussions on these questions in the major areas of importance to NRM in the sub-region; air, water, coastal and marine, biodiversity, Indigenous issues and land.

The Interim Gascoyne-Murchison NRM Council was keen to acknowledge that natural resources were used and valued by many people. For example, the landscape at any one place in the Region may have pastoral uses overlapping biodiversity values, overlapping Indigenous cultural values, overlapping tourism uses. Therefore, assets and threats were identified according to the primary areas of resource use and management in the Region:

- pastoral land management;
- horticultural land management;
- conservation and biodiversity management;
- traditional land use and management;
- local government management;
- mining use;
- tourism and recreational use; and
- fisheries and aquaculture resource management.

The Goldfields-Nullarbor NRM Group adopted a similar approach, also recognising that the Rangelands are frequently characterised by multiple, overlapping uses of land (eg concurrent mining and pastoralism within a land management unit) and by multiple, overlapping interests of land users (eg economic and cultural aspirations of Indigenous land managers).

As well as asset identification work at sub-regional level, a Technical Working Group comprising State agencies assisted the Rangelands NRM Co-ordinating Group to identify broad scale assets within the Region's landscapes, waterscapes and seascapes.

The Co-ordinating Group and sub-regional groups acknowledge that there is still significantly more work to be done in refining asset identification. Additionally, they acknowledge that in some areas very little work has so far taken place, but are committed to overcoming these gaps.

1.6 How Targets Were Set

As well as identifying key assets in the Rangelands, each of the sub-regional NRM groups coordinated processes for setting RCTs and MATs. In each case these were set according to the approaches described above. The Rangelands Technical Working Group also assisted in developing RCTs for the Region.

Not surprisingly, there was considerable overlap and similarity of targets set in the sub-regions. To address this, the Rangelands NRM Co-ordinating Group analysed all of the targets and, where sufficient similarity existed between sub-regional targets, expressed them as whole-of-Rangelands targets. Where a target addresses a specific issue or geographic area in a sub-region, it is expressed to reflect that.

Where possible targets have been set to meet "SMART" (Specific, Measurable, Achievable, Realistic and Time-bound) criteria, however the Group acknowledges that over time the SMART-ness of several targets requires refininement.

1.7 Challenges for Regional NRM Planning in the Rangelands

Both in engaging broadly with the community, and in setting and prioritising targets, the Co-ordinating Group acknowledges that it still has more work to do. It accepts that up to this point there has been a limit to what it has been able to achieve as a consequence of a number of challenges it has been presented with in undertaking regional NRM planning and delivery in the Rangelands.

The nature of Western Australia's Rangelands presents particular challenges for engaging stakeholders on NRM. Most obvious is the challenge of distance and isolation in a Region covering almost 90 percent of the State, but with a small and sparsely distributed population. Under these circumstances, community engagement becomes very resource hungry in terms of time and money. Consequently, there is a limit to the level and extent that can be achieved.

Challenges related to distance and isolation also mean there is a relatively low level of awareness of NRM processes and policies in many parts of the Region. This has presented a further obstacle as some stakeholders lack immediate capacity to provide input into Strategy development processes. As a result, the Rangelands NRM Co-ordinating Group and its staff have had to focus on awareness-raising in some areas to bring stakeholders up to a point where they are familiar with the targets-based approach of the regional NRM planning process. Stakeholders have essentially had to learn new terminology, with a strong focus on priorities, targets and monitoring and evaluation. This is quite different to the language and NRM delivery processes that many Rangelands stakeholders have previously been familiar with, such as the National Landcare Program (NLP).

A further (and possibly the most significant) challenge facing the Rangelands NRM Co-ordinating Group in developing the Strategy and engaging with stakeholders, has been the very short timeframe in which to undertake the process. Whilst the Group appreciates the need to meet a tight deadline, this has meant that community engagement in some areas has not been ideal. However, the Co-ordinating Group is committed to on-going engagement in these areas post-accreditation to provide opportunities for input for the broad range of the Region's stakeholders.

1.8 Other Enagement Process in Western Australia's Rangelands

Some of the issues being considered through the regional NRM process in the Rangelands are also under consideration at a State level through the Government's review of the pastoral industry. This review has wide-reaching implications for rangeland management generally, with the Government establishing Working Groups to look at:

- Pastoralism for Sustainability;
- Alternative Models of Land Tenure;
- Pastoral Industry Economic Monitoring Requirements;
- Access to Pastoral Land;
- Aboriginal Access and Living Areas; and
- Pastoral Rating.

The Working Groups comprised representatives from State agencies, local government, Indigenous groups, the pastoral industry, the conservation movement, mining and tourism interests. Two major public forums were held to discuss the review, and the Government sought considerable public comment on the Working Groups' reports. In addition, the Government established a Rangelands Working Group, of which the Rangelands NRM Co-ordinating Group was a member, to advise it on the reports. At the time of writing this Strategy the Government is yet to make a formal response on the reports of the Working Groups.

However, several of the issues covered and recommendations made by the Working Groups are relevant to NRM. As an outcome of the review process, the Government has flagged the establishment of a peak "Rangelands Council" to:

- provide linkages between stakeholders with interest in rangeland management;
- bring stakeholders together to address competing resource use issues;
- administer an overarching framework for rangeland management; and
- provide policy advice to Government on sustainable rangeland management.

This Council and the Rangelands NRM Co-ordinating Group would need to work together closely to ensure consistency of targets and objectives for sustainable rangeland management.

Furthermore, the process highlighted a number of key issues about the future of rangeland management, which also have relevance for regional NRM planning including:

- need for planning to take place in accordance with statutory planning requirements;
- tenure arrangements should support multiple uses and values; and
- on-going land use and management should be subject to reporting on social, economic and environmental outcomes.

1.9 Policies, Strategies and Legislation

There are a large number of policies, strategies and Acts related to NRM that have implications for rangeland management. In many cases these provide a foundation and context for NRM actions, with some targets in the Strategy related to current statutory responsibilities. Additionally, a number of targets highlight the need for integration of policy and legislation, and in some instances the regional planning process can provide a forum for facilitating this integration. For example, the Ningaloo Coast Regional Strategy – Carnarvon to Exmouth sets direction on appropriate management of the Gascoyne's unique coastal and marine assets and the Rangelands NRM Strategy needs to be consistent with a policy document of this nature.

The Rangelands NRM Strategy however, has no intention duplicating these policies and strategies but will complement them where it is appropriate. In fact, in many cases the Strategy, and the regional planning process it is based on, can provide a mechanism for achieving the intentions and goals of local, State and Australian Governments. However, it should be noted that the Strategy in itself is not a vehicle for developing and implementing new policy directions. This remains the responsibility of governments.

There are however, a number of national policy initiatives that are of direct relevance to the Strategy and which will drive its delivery and implementation. They are:

- National NRM Accreditation Criteria (and guidelines);
- National Framework for NRM Standards and Targets;
- National NRM Monitoring and Evaluation Framework; and
- National Capacity Buidling Framework.

A more detailed list of policies, strategies and legislation can be found at Appendix IV however, it is acknowledged that this is an incomplete list to revised when the Strategy is reviewed.

1.10 A Vision for NRM in the Rangelands

People's Aspirations

Through engagement processes to develop the Rangelands NRM Strategy, people from a broad cross section of the community, government and industry have had opportunities to reflect on, and outline, their long term goals and aspirations for the Region. Whilst the focus of consultation has been on NRM, people have also inevitably expressed the need to protect and sustain rangeland industries and communities, highlighting the inseparable nature of NRM from social and economic issues.

In the absence of a formal community "vision" for the Rangelands, the following quotes, taken from engagement activities during the regional planning process, highlight to some extent peoples' aspirations for the Region. As well as aspirations for the future, these statements also highlight a number of the key threats to sustainable NRM in the Region and activities that people believe should be in place to address them. They can be summarised under a number of important areas regarding rangeland management:

Multiple Use

People want to see…

"Regional decision making resulting in outcomes based on Regional needs and priorities that assist in increased involvement of Regional communities, and which improve the credibility of the project in the Region." (Gascoyne-Murchison)

"Diverse communities undertaking diverse, overlapping land uses in healthy, biodiverse ecosystems." (Goldfields-Nullarbor)

"Weed and vermin-free landscape inhabited by caring, healthy, educated people, living in peace with each other. Mix of well balanced grazing, timber, mining, tourism and other industries." (Goldfields-Nullarbor)

"A dynamic Region that is socially integrated, environmentally responsible and economically proactive and diverse" (Kimberley)

Indigenous Involvement in NRM

Indigenous people explained that…

"Our river holds our culture, our lives, our future." (Kimberley)

"Fires are killing everything. In 50 to 60 years, could turn into desert; all those trees got birds, possums. Killing our animals in trees, cooking our lizards, goanna and snakes who are buried in the ground." (Kimberley)

"Tourists all around, never ask us what they can do. They never tell us what they want to do. Pouring like water; white tourists everywhere on our country. I am from Wunambal Gaambera, we are wondering what happens to these people, spread out, what they want, they don't tell us. They should recognise people who are sitting in country before. We belong to country. We should be together, talking together, painting, lailai." (Kimberley)

"One of the assets we have is Indigenous knowledge of country and of biodiversity. I'd like to see NRM integrate Indigenous knowledge into the plan by June 2005 and on-going engagement with Indigenous people." (Pilbara)

"It is important that we work to embrace this opportunity for land management for Indigenous people. It is as we have said, Desert – Rivers – Sea – we want to be able to get future generations having working relationships with the wider community. Indigenous people want more ownership of governance on our country. Want to embrace working relationships with the NRM process, communicate to work together, all tribes represented in the Rangelands." (Pilbara)

"We need to keep culture strong, get country caring – work in our country and have a say about what is to be done. We 'feel' the country when something is wrong or something is right, but we can't go to it to help heal the country. For Millstream, we need to work together to strengthen the spiritual connection." (Pilbara)

Sustainable Management Practices

People who use natural resources believe that…

"Peoples demands on resources do not exceed the capacity of the earth" (Kimberley)

"Unmanaged growth is one of the biggest risks, it is most important to develop an industry based on a set of guidelines for sustainability." (Gascoyne-Murchison)

"The assets currently under our control should be handed to the next generations in an improved condition and for the general population to have a greater understanding and value of the Australian outback." (Goldfields-Nullarbor)

"The single biggest action that needs to occur to preserve the natural resource is educating managers on appropriate grazing regimes taking into account climate change and drought management." (Gascoyne-Murchison)

"While the natural resource management measures currently in place to protect the key fisheries assets are sound and adequate for the job, there is always the capacity for them to be better." (Gascoyne-Murchison)

Protection and Management of Biodiversity

People would like to see…

"The cultural, social, environmental and economic choices we make are integral to maintaining biodiversity. We recognise that diversity can make us whole" (Kimberley)

"Biodiversity is the singular issue, it encompasses all aspects of the environment and community – maintaining biodiversity ensures healthy natural systems, healthy people and communities and healthy economies" (Kimberley)

"Complete return of all plant and animal species that have not become extinct." (Goldfields-Nullarbor)

"I think the challenge is learning to live in our environment and with our environment. I'd like to see the NRM processes address our need to learn to live with the environment." (Pilbara)

"Harmonious relationship between human residents in the Rangelands and the ecosystem." (Goldfields-Nullarbor)

Healthy Communities

For their communities people want…

"The community educated and actively involved in protecting the environment" (Kimberley)

"To include ritual and ceremony as a way to give respect to ecology and people before us. It is a powerful tool the concept that environment is fully alive and needs recognition" (Kimberley)

"People on the land to manage healthy landscapes and maintain or return to a productive, functional state." (Goldfields-Nullarbor)

"An area that is productive and supporting larger populations. It will be a clean environment with good telecommunication facilities where families are not disenfranchised by not living in coastal cities." (Goldfields-Nullarbor)

"A vibrant economically and socially sustainable Goldfields-Nullarbor community that is able to freely access a wide range of relevant services and infrastructure and instigate institutional change throughout the three tiers of government." (Goldfields-Nullarbor)

"Integrated and sustainable management in marine and coastal ensuring to maintain natural integrity and species diversity" (Kimberley)

Managing Access

With regard to access in the Rangelands, people believe that…

"We need more development in coastal areas to meet the demands of a growing tourism market." (Gascoyne-Murchison)

Integrated Planning

People want to be part of the planning process. They said…

"It is important that pastoralists as a group believe they have some ownership of the natural resources they use and that their collective priorities and decisions will be given due regard by government, and acted upon." (Gascoyne-Murchison)

"Develop a coordinated approach to each issue that can be adapted across the various local authorities and other government agencies." (Gascoyne-Murchison)

"A role I bring (to the NRM process) is to integrate the NRM Strategy goals into "workable" industry goals. An outcome I'd like to see is to get specific actions (for land management) into the Strategy, to tie together the ad hoc actions that are happening at the moment, and to input industry resources into the right gaps." (Pilbara)

"It has got to have better representation this time. I'd like to see the pastoral owners, government, and mining sector embrace it with the same spirit, to work towards the common goal to conserve country." (Pilbara)

A Regional Vision for the Rangelands

The protection and sustainability of the Rangelands' industries, natural resources and communities are also reflected in a vision for the Rangelands developed by the NRM Council (September 2003). This forms the basis of the Rangelands' vision in the State Sustainability Strategy (September 2003).

The Rangelands NRM Co-ordinating Group has adopted this as a broad statement of its aspirations for the Region. It is:

> Western Australia's vast landscape, intricate web of biodiversity and natural resources will be preserved, managed and used sustainably for the common good, and closely involve the community in management and planning processes that are transparent, inclusive and based on a clear set of environmental values and objectives.
>
> The Rangelands will have a robust, vibrant economy based on the sustainable management of economic, social and environmental resources and a strong partnership approach within and between Regional communities, industry and Government.
>
> The close, traditional associations of Indigenous people with components of biological diversity and land management will be recognised and integrated to achieve contemporary environmental values and objectives.

In support of this vision, the Council also described a future visual picture of the Rangelands:

> The Rangelands will remain sparsely settled but will have established a higher quality of life and will meet the needs and aspirations of all its citizens, including Indigenous communities. The Rangelands will have developed as a model of environmental management where growing economic strength has been complemented by a diverse natural environment protected from

environmental degradation. The community will feel more empowered by a consultative planning process that delivers a high degree of consensus on major development questions.

There will be an improvement in biodiversity health across the landscape through combined actions targeting the protection, restoration and sustainable use of plants, animals and other native organisms within the Rangelands.

Sustainability will be accepted as a fundamental goal and all land managers, including the Crown, will follow Regional indicators and targets for environmental management. The network of parks and reserves has expanded, including an established comprehensive, adequate and representative reserve system and Aboriginal groups have title to larger areas, whilst mining continues, but none of these totally dominate the landscape. All Rangelands land managers take responsibility to control pest plants and animals and fire, and work actively to rehabilitate degraded areas.

Human activity in the Rangelands will be richer and more diverse. There are many different kinds of businesses within resource specific niches in the Rangelands operating on an ecologically sustainable basis including horticulture, aquaculture, native food industries, mining, tourism and rural retreats. Habitats that only occur in areas attractive to human activity are carefully protected. Traditional knowledge will be integrated into decision making at all levels.

There will be a new generation of pastoral lease managers who adopt risk management approaches to business and grazing management, focused on the condition of the land and its vegetation. Monitoring and evaluation of natural resource conditions will be a condition of leases and open up marketing opportunities for 'ecologically sustainable' products. The range of livestock grazed and the mix of livestock reflect climatic, economic and market demands. Pastoralists have adopted new technology and best practice management systems and many have diversified their enterprises. Government regulations and incentives have supported these changes, but the primary driver of change has been the pastoralists' own business decisions.

Marine and coastal biodiversity will be managed and protected through an established comprehensive and representative system of secure marine protected areas as well as through the identification and protection of areas of high conservation significance from threatening activities.

This Regional vision and visual picture is highly consistent with many of the aspirations expressed by people during engagement processes to develop the Rangelands NRM Strategy. In particular the need to manage multiple use, increase Indigenous participation in NRM, implement sustainable management practices and protect and manage biodiversity.

SECTION II - THE STATE OF THE RANGELANDS

2.1 Introduction

The aspirations and vision outlined in the previous section highlight the inseparable nature of the region's natural resource assets from the people that use, manage and value them. It also highlights the importance of managing and accommodating multiple uses, management regimes and values, and that in any given context, people's actions have impacts on several natural resource assets at the same time.

This adds a level of complexity for NRM. Natural resource assets cannot be considered in isolation or separated from the people that use, manage and value them. At the same time however, it may be unrealistic to expect one group of stakeholders to be solely responsible for managing a particular asset, or set of assets, for the range of multiple outcomes desired by the wider community.

The need to accommodate multiple use, management regimes and values, and achieve multiple NRM outcomes is highlighted in *Rangelands – Tracking Changes* (National Land and Water Resources Audit, 2001, p. 10). Using Carnarvon as an example, it points out that the town supports a valuable horticultural industry which relies on alluvial soils of the Gascoyne River and its underground aquifers. The aquifers are in turn fed by rainfall from the Gascoyne catchment falling some 650 kilometres away on land mainly used for pastoralism and nature conservation. Salt mining also occurs near the town and is a major contributor to the region's economy. Furthermore, many tourists are attracted to the area to experience the outback and adjoining coastline. The townsite of Carnarvon itself provides services to each of these industries, is an important land user and manager in its own right.

The challenge for NRM is to take these multiple asset uses and values into account through consultative processes and attempt to determine appropriate trade-offs between them, which provide the largest public benefits. This often requires changes to land use and management, and acceptance of a range of values for natural resource assets.

2.2 A "scapes" Approach

To deal with the issue of multiple uses, management regimes and values, the Rangelands NRM Strategy examines natural resource assets in the context of the landscapes, waterscapes and seascapes within which they occur and where they are used, managed and valued. For example, in the "scapes" approach an assessment of "landscapes" looks at abiotic (non-living) resources such as landforms and the physical and chemical aspects of soils, along with terrestrial, biotic (living) resources. This recognises that land and terrestrial biodiversity assets are intrinsically linked and that targets, and actions to manage them, should be closely aligned for an integrated approach. Similarly within waterscapes and seascapes, living and non-living assets are identified and the ways in which they are used, managed and valued are discussed.

This approach also recognises that people do not tend to interact with assets singly when using, managing or valuing them. They most often interact with, and impact upon, several of them at any one time. For example, pastoral land managers use and manage soil, water and native vegetation resources, fishermen need clean seas and access to marine biodiversity, whilst reserves provide recognition of the values of various landscapes, native vegetation and animals.

Whilst this approach helps conceptually to provide a level of integration between assets and their use, management and value, it cannot overcome all of the complexity associated with their interconnectedness. For example, subterranean assets such as caves and aquifers do not fit exactly within any of the three scapes defined above and are included in both the land and waterscapes sections. In fact, there is probably no one schema for addressing all of these issues in their entirety. To this end the strategy acknowledges that the "scapes" approach has its limitations, and that there are obviously linkages between the scapes themselves. Therefore, in only dealing with land and terrestrial

biodiversity assets under landscapes for example, the strategy is not ignoring the impact water has on landscape processes and land uses, and vice versa. It is merely an attempt to provide a simple framework for demonstrating linkages between natural resource assets and their use, management and value in the Rangelands.

2.3 The Integrating Nature of Biodiversity

Whilst biodiversity could be dealt with as an asset class in its own right, under the "scapes" approach it is a linking feature between the scapes. Biodiversity exists in all three scapes and very often provides the core resources which are used, managed and valued by rangeland stakeholders.

Biodiversity is defined in *The National Strategy for the Conservation of Australia's Biological Diversity* (Commonwealth of Australia, 1996) as "the variety of life forms: the different plants, animals and micro-organisms, the genes they contain, and the ecosystems they form." Consistent with this definition, a number of important elements are acknowledged:

- **genetic diversity** – including the variation (and genetic distance) within and between populations of individual species, and between different species, including taxonomic and phylogenetic diversity;
- **species diversity** – including both the number of different species and the relative abundance of each species within and between sites, habitats or geographical areas;
- **natural assemblages of living things** – the variety of biotic communities and other living assemblages, or the living components of a specific ecosystem; and
- **structural diversity** – including the variety of physical growth forms exhibited by organisms, particularly in relation to vegetation and its regeneration following disturbances such as fires or storms.

Biodiversity is important not only for environmental reasons, but also for human uses and values. The following set of uses and values gives some definition to the human importance attached to biodiversity, and underlines the importance of conserving natural biodiversity. These uses and values include:

- ecosystem services;
- landscape function;
- economic value;
- spirituality and sense of place;
- educational and scientific value;
- amenity value; and
- habitat value.

Biodiversity underpins core life functions for all living organisms through ecosystem services such as clean air, clean water, nutrient cycling and soil fertility. However, these functions are under increasing pressure from human activity.

A detailed analysis of biodiversity assets, based on a hierarchy developed by Carter and Wallace (unpublished), can be found in Appendix V. Figure 3 provides a diagrammatic representation of this hierarchical flow from living assemblages to populations and species, and the major components of each.

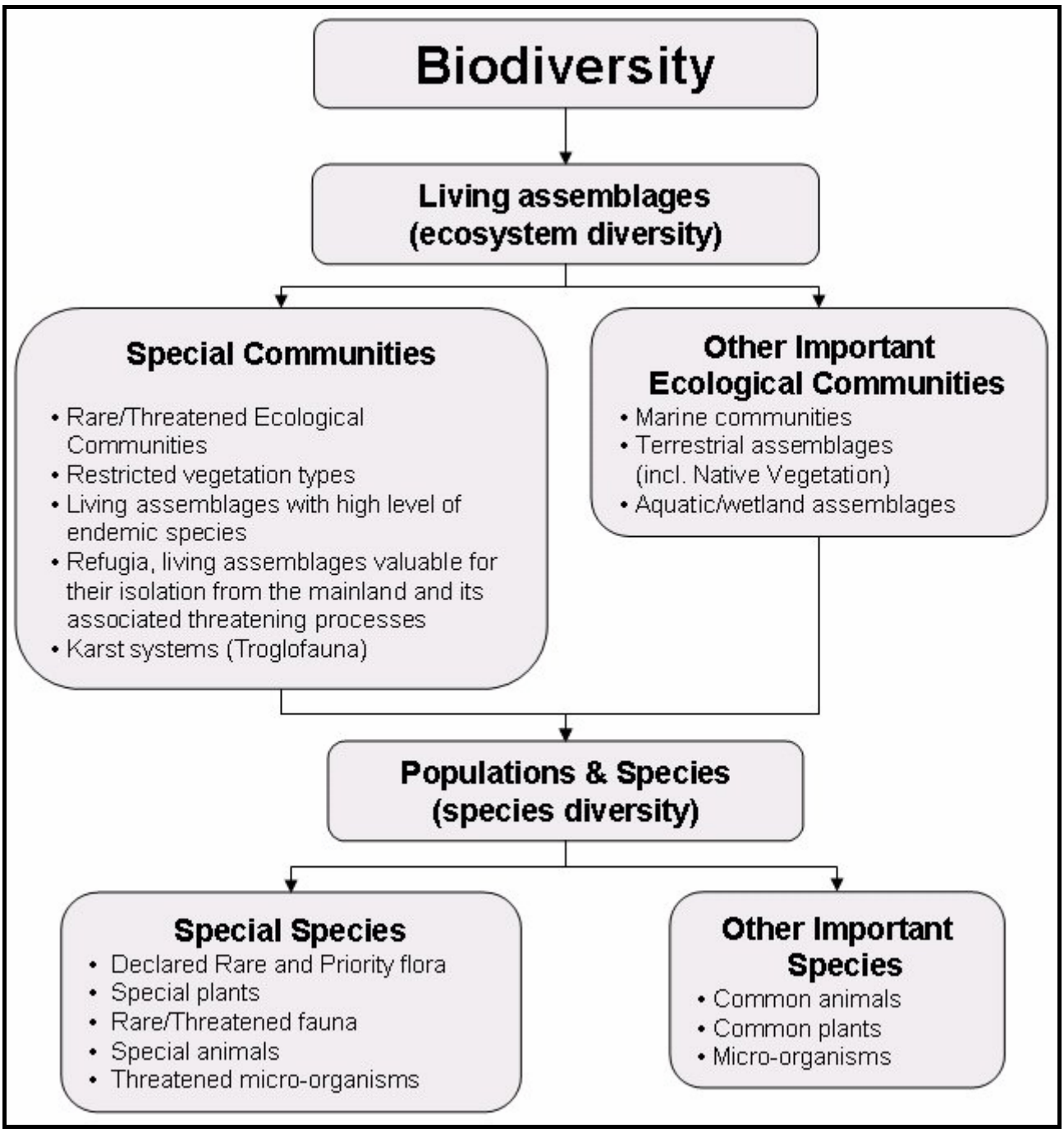


Figure 3: Diagrammatic Representation of Biodiversity Assets in the Rangelands NRM Strategy.

2.4 How Targets are presented in the "Scapes"

Following descriptions of the key assets in each of the scapes, tables are provided in the Rangelands NRM Strategy showing the RCTs and MATs that relate to particular elements of the scape. Table 1 below provides an example of how RCTs and MATs are presented in the strategy.

The icon in the far left-had column identifies the NRM issue that each MAT addresses. This is followed by the MAT, its geographic focus, associated actions, possible partners for implementation and the RCT it contributes to. The far right-hand column shows priority of the MAT as a consequence of the relative importance of issue that it addresses (represented by the figure 1), and the feasibility and cost effectiveness of implementation (represented by the letter A) (priority is explained further in Section IV and Appendix IX).

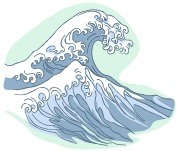
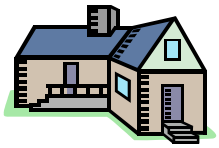
Table 1: Example NRM Targets Table

Management Action Targets		Geographic Focus	Actions	Potential Partner Groups	Links to RCTs	Priority
2 	**L11**. By 2010 implement programs that demonstrate best practice approaches to landscape recovery in priority areas of the Rangelands	Regional Priority Areas	• Identify priority areas in consultation with all stakeholders by 2006 (e.g. top of catchments) for program implementation of landscape recovery • Investigate and develop landscape recovery models applicable to the Rangelands • Investigate and promote the use of local, native species for landscape rehabilitation and pasture improvement • Identify and promote case studies of successful landscape recovery • Implement design actions in identified priority areas including Roderick River	Research institutions State government Industry groups	RCT3 RCT5	1B
Management Action Targets		**Geographic Focus**	**Actions**	**Potential Partner Groups**	**Links to RCTs**	**Priority/ Importance Threshold**
Key Issue that MAT addresses	Management Action Target	Area that MAT relates to.	Actions that will lead to the achievement of the management action target	Broad statement of partners that are integral to achieving MAT	The RCT that the MAT contributes to achieving	Level of priority for action

Issue Symbols Used in Target Tables

To provide a link to the issue that each MAT primarily address, the following symbols, shown in Table 2, have been used in the RCTs and MATs tables as a visual representation of the "key NRM issues" used in the prioritisation process (explained in greater detail in Section IV and Appendix IX).

Table 2: NRM Issues Symbols

Symbol	Issue No.	Description	Symbol	Issue No.	Description
	1	Declining Soil Condition		9	Declining Marine Native Species and Communities Integrity
	2	Declining Native Vegetation Integrity		10	Decreasing Primary Productivity
	3	Declining Inland Aquatic Water Quality		11	Low Community Capacity for NRM
	4	Altered Water Regimes		12	Defficient Planning for NRM
	5	Declining Water Quality Supply		13a	Poor Maintenance of Cultural Knowledge and Values
	6	Declining Marine Water Quality		13b	Poor Maintenance of Heritage Knowledge and Values
	7	Declining Terrestrial Native Species and Communities Integrity		14	Declining Air Quality
	8	Declining Aquatic Native Species and Communities Integrity			

2.5 Cultural Heritage and Capacity

2.5.1 Cultural Heritage

Cultural heritage plays a significant role in engaging the community in NRM. Consequently it is important that all community members have opportunities to be engaged, involved and included in culturally appropriate ways in developing and implementing NRM actions.

Aboriginal culture in the Rangelands is as diverse as the country itself, and there are many traditional owner groups that identify closely with their specific country. This connection to land is through traditional law and obligation to country, values connected to it and traditional and contemporary knowledge. For Aboriginal people there are strong cultural and social aspects within their NRM activities demonstrating a drive to achieve culturally and socially sustainable outcomes at the same time as environmental and economic ones.

Increased participation in protecting and managing the cultural and natural environment is one of the most pressing concerns emerging from consultations with Aboriginal people. The engagement of Traditional Owners in NRM in the Rangelands is therefore specifically important to help continue the sustainability of the country that has been cared for by Aboriginal people until recent history.

There are many opportunities for involving Traditional Owners in NRM projects including:

- integration of traditional law and custom with contemporary means when caring for country;
- support of intergenerational transfer of skills and knowledge on natural and cultural resource management practices;
- promotion and preservation of endangered Aboriginal languages;
- development of guidelines for people from outside the area when working in partnership with Traditional Owners; and
- partnerships between Aboriginal and non-Aboriginal people and agencies to create management regimes that best suit both the country and the people living on the land.

The need to gain a greater involvement of Indigenous people in the NRM planning and implementation processes is growing more pressing with time, both from a cultural and NRM perspective. This is particularly due to the remoteness of the region and the growing threats that the Rangelands faces such as unsustainable land use, unmanaged visitor access, inappropriate fire regimes and feral weeds and animals. There will be a need to ensure adequate planning and capacity building to achieve and retain increased engagement and participation of Aboriginal people in NRM projects.

2.5.2 Capacity

The management of natural resources is critically connected to the capacity of all land managers and the wider community to participate effectively in NRM. In the Rangelands, where many stakeholders have had only little exposure to NRM so far, this is particularly important. Many stakeholders also live in remote areas where access to resources is difficult and often expensive.

The implementation of this strategy will require effective capacity building to provide relevant information, support, skills and tools to increase participation and the capacity of people to manage natural resources. Efforts will be needed to increase knowledge and understanding and to empower the community in the understanding and management of the diverse values of their natural environment.

Consequently the Rangelands NRM Co-ordinating Group recognises the need to address these as considerations across landscapes, waterscapes and seascapes, and in support has developed two RCTs for culture and heritage which apply universally. They are:

2.5.3 Cultural Heritage and Capacity RCTs

RCT 1: Community capacity for natural resource management is significantly enhanced by 2025, as measured by participation in NRM projects

RCT 2: Culture and heritage for the Rangelands are conserved and increasingly valued by the community by 2025

MATs related to cultural heritage and capacity appear throughout the scapes.

In general, MATs focused on culture and heritage relate to capturing and preserving traditional and more contemporary knowledge to enhance NRM planning and actions. They also relate to the need to improve the community's ability to recognise, promote and protect traditional and contemporary heritage, including the built environment.

2.6 Landscapes

2.6.1 Introduction

This section addresses the Rangelands' landscape assets of land and terrestrial biodiversity. It highlights:

- the condition of land and terrestrial biodiversity assets;
- the major uses and values associated with them;
- the major threats to them; and
- some of the current activities being undertaken to address these threats.

It then defines the targets and actions that stakeholders in the Region believe should be in place to protect regional landscape assets.

This section also includes a brief discussion of air quality as a NRM asset. It is dealt with in this section as actions affecting air quality are primarily a result of land uses such as mineral and petroleum refining (where emissions can affect air quality) and pastoralism (where altered fire regimes and vegetation loss causing dust generation can affect air quality). These issues are important throughout the Rangelands, but are of particular interest to communities in the Kimberley, Pilbara and the Goldfields.

Appendix I also provides some more detailed information about major uses, values, and threats of natural resource assets in the sub-regions.

2.6.2 Land

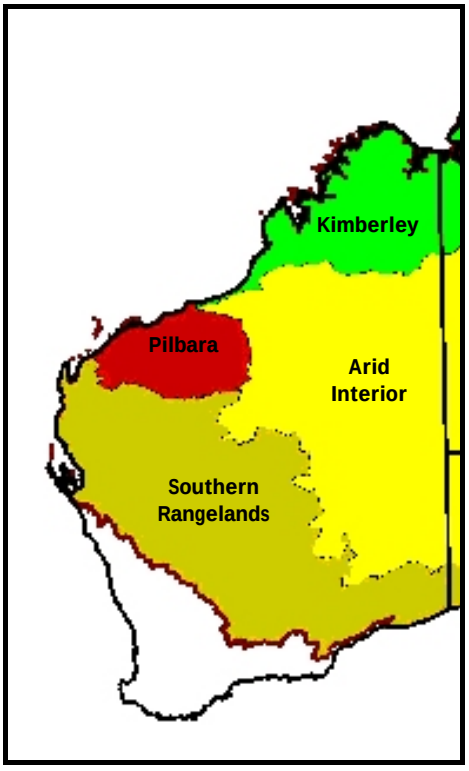


Figure 4: Rangelands Land Asset Zones

At a whole-of-Rangelands scale, land assets have been broadly classified by different authors assessing a variety of bio-geographical, physical, socio-economic and land use attributes. Fisher *et al* (2004) developed four land asset zones relating to land uses and bio-geography (Figure 4). These are the

Kimberley, Pilbara, Southern Rangelands and the Arid Interior. Whilst similar terms are often used with reference to the pastoral industry, the zones used here are a combination of land use (pastoral vs non-pastoral) and Interim Biogeographical Regionalisation of Australia (IBRA) sub-regional boundaries. That is, the boundaries of the zones are determined by IBRA sub-region boundaries rather than land use boundaries. As a generalisation, the Kimberley, Pilbara and Southern Rangeland zones are dominated by pastoral land use, whilst the Arid Interior is dominated by non-pastoral land use.

The zones do not match the NRM sub-regional boundaries but are considered the best way to describe land assets for the purposes of the Rangelands NRM Strategy.

The Department of Environment and Heritage (DEH) has developed the IBRA sub-regional boundaries, which should be considered the most comprehensive description. A more detailed description of the Rangelands IBRA bioregions is provided in the next section on terrestrial biodiversity.

Landforms and geological features are also land assets to consider, as these have particular values in terms of natural heritage, cultural and spiritual value and as icons for tourism and Western Australian identity. They include features such as ranges, gorges, cliff formations, meteor craters, breakaways, karst systems and many more.

Tinley (1986) developed a set of ecological regions based on hydrology as the main process affecting land asset management. Essentially, land within externally drained catchments (flowing toward the coast) has major downstream effects. That is, rainfall in the catchment has predictable, important impacts downstream on land, water and coastal and marine assets as well as rangeland values such as tourism, horticulture and conservation. This includes insidious, on-going erosion and episodic (often catastrophic) events such as major flooding. In contrast, rainfall on land in internally drained catchments, or areas where there is little or no drainage, has off-site impacts which are limited in spatial scale. Whilst the impacts may be very important within the internally drained catchment, the total area of downstream impact is typically less than for externally drained catchments, at least in the Western Australian Rangelands.

Kimberley

The Kimberley contains the IBRA 5.1 sub-regions of Central Kimberley (CK1-3), Dampierland (DL1-2), North Kimberley (NK1,2), Ord Victoria Plains (OVP1&2) and Victoria Bonaparte (VB1).

It has a hot climate with strongly seasonal rainfall and there is a pronounced north-south rainfall gradient. As a result, southern parts of the zone are semi-arid, with less reliable rainfall and higher annual temperature range. Virtually the entire zone drains to the Timor Sea Drainage Division, with three major hydrologic process units, which are the:

- northern ria-coast[1] drainage off the Kimberley Plateau;
- western drainage division received by King Sound (Fitzroy and Lennard Rivers and lesser systems); and
- eastern drainage area entering Cambridge gulf (Durack and Ord Rivers and lesser systems) (Tinley, 1986).

Vegetation is generally characterised as tropical savanna, although there is considerable variation throughout, determined by rainfall, topography and soils. The most extensive vegetation is eucalypt woodland and open woodland, but there are also areas of hummock grassland, tussock grassland and acacia open woodland. The ground layer is almost always dominated by grasses, with grazing mostly based on native, perennial tussock grasses and in some instances introduced buffel and birdwood grasses.

[1] A long narrow coastal inlet that gradually decreases in depth and width from its mouth inland, usually surrounded by hills, and formed by the flooding of river valleys.

Most of the zone is dominated by pastoral land use, with large areas of Indigenous held land, much of it on pastoral leasehold. Pastoral leases are typically between 200,000 and 350,000 hectares with livestock carrying capacity ranging from about six hectares per Cattle Unit (approximately one hectare per Dry Sheep Equivalent [DSE]) to 280 hectares per Cattle Unit (40 hectares per DSE) (Appendix VI, Attachment 1). The major pastoral system is extensive grazing of cattle. Management is most intensive in the more productive areas, such as the valleys of the Ord-Victoria and Fitzroy.

In terms of net primary productivity and livestock carrying capacity, the Kimberley is by far the most productive zone on a per hectare basis. Average carrying capacity per station is 35 hectares per Cattle Unit, which is three times more productive (in a pastoral sense) than in the Southern Rangelands and about double that of the Pilbara. This is despite the fact that the zone contains large areas of relatively unproductive, hill range and spinifex lands.

The Kimberley also contains the high value land asset of the Ord River Irrigation Area, with extensive irrigated agriculture and horticulture. Detailed information on the Ord is included in Section III.

Pilbara

The Pilbara zone comprises the four sub-regions of the Pilbara IBRA 5.1.

It is characterized by a hot, arid climate and virtually all the zone drains to the coast. The major hydrologic process units that occur in this zone are the:

- De Grey and lesser rivers off the northern divide of the Chichester Range; and
- Fortescue system (Tinley, 1986).

The major landforms of the zone are extensive coastal plains and ancient inland ranges and plateaux, with some areas of alluvial and basalt-derived plain. The most extensive vegetation type is hummock grassland, and there are also significant areas of tussock grassland, acacia woodland and open woodland. There are smaller areas of chenopod shrubland and eucalypt woodland, which occur primarily on floodplains and along drainage lines.

The majority of the zone is under pastoral leasehold tenure (58 percent) but there are also large areas of UCL (20 percent). There are also significant areas under Aboriginal ownership (10 percent) and within conservation reserves (68.5 percent). Both UCL and conservation land tend to be on areas of hummock grassland because of the low value for grazing.

Pastoral leases are typically between 200,000 and 300,000 hectares, although smaller on the more productive coastal areas. Livestock carrying capacity ranges from six hectares per Cattle Unit (approximately one hectare per DSE) to 280 hectares per Cattle Unit (40 hectares per DSE) (Appendix VI, Attachment 1). The average carrying capacity per lease is about 70 hectares per Cattle Unit (10 hectares per DSE). Few sheep remain in the Pilbara and almost all domestic livestock are cattle.

A small proportion of the landscape also supports the mining and petroleum industries in the Pilbara, from which the State and indeed the country derives significant economic benefits. The values of these industries are summarised in the next section dealing with use and value of land assets.

Southern Rangelands

The Southern Rangelands zone comprises the IBRA 5.1 sub-regions of Carnarvon (CAR1,2), Coolgardie (COO1-3), Gascoyne (GAS1-3), Geraldton Sandplains (GS1), Great Victoria Desert (GVD1), Hampton (HAM), Murchison MUR1,2), Nullarbor (NUL2,3) and Yalgoo (YAL).

It contains arid and semi-arid areas, characterised by a hot dry climate in northern areas and a more moderate climate in the south. Rainfall is winter dominated throughout much of the zone, but tends bimodal or evenly distributed towards the Nullarbor. The north-western part of the zone drains to the coast, the middle part drains internally (although paleo-drainages are known to flow infrequently to the

coast several times per century) whilst the Nullarbor has internal karst drainage with the groundwater system sheeting slowly south to the southern ocean. The hydrologic process units that occur in this zone are:

- most of the Ashburton system (although sections of this system are in the Pilbara); and
- the Gascoyne, Wooramel and Murchison systems, and lesser rivers such as the Minilya and Lyndon.

Vegetation is predominantly chenopod and acacia shrublands and woodlands, but many vegetation types can be found. Much of the area can be broadly described as the "mulga zone". It contains mulga, eucalypt woodlands and chenopod shrub lands.

Pastoralism is the dominant land use with cattle stations dominating towards the north, and sheep stations dominating towards the south and west. However, in recent years many stations have begun to run sheep and cattle together, and a significant proportion of station income has come from trapping and selling unmanaged goats.

Livestock carrying capacity ranges from about seven hectares per DSE (50 hectares per Cattle Unit) on chenopod shrublands to about 30 hectares per DSE (210 hectares per Cattle Unit) on heathlands (Appendix VI, Attachment 1). The average carrying capacity is about 16 hectares per DSE (110 hectares per Cattle Unit), which is about one third that of the Kimberley.

The Southern Rangelands is also home to the high value Carnarvon horticultural precinct which relies on rich alluvial soils of the Gascoyne River. A number of inland horticultural opportunities are also being investigated.

Arid Interior

The Arid Interior zone comprises the IBRA 5.1 sub-regions of Central Ranges (CR1), Gibson Desert (GD1&2), Great Sandy Desert (GSD1-6), Great Victoria Desert (GVD2-4), Little Sandy Desert (LSD1&2), Nullarbor (NUL1) and Tanami (TAN1).

Its climate can be described as hot, arid desert, which includes some of the driest parts of the continent. Rainfall seasonality is variable but tends to be winter dominated in the south and summer dominated in the north. The drainage of the Arid Interior is predominantly internal or non-existent.

Hummock grassland is the major vegetation type, with smaller areas of eucalypt and acacia open woodlands, and acacia forests and woodlands.

Whilst there are some pastoral leases on the western and northern margins of the Arid Interior, the zone can be thought of as largely "non-pastoral" with most land being UCL, Aboriginal reserves or leases and conservation reserve. For more information on Indigenous Land Use see Appendix VII.

Pastoral Land Assets at Finer Scale

The above description identifies land assets at a broad regional scale. At finer scales such as sub-region to district, station, reserve and even paddock, other data sets can be used to identify land assets. Resource inventory information is available for more than 80 percent of the pastoral Rangelands, which have been mapped to land system level through Rangeland Land System Surveys (Figure 5) undertaken by the Departments of Agriculture and Land Information.

Native vegetation has been mapped at a scale of 1:250,000 for the entire Rangelands by John Beard and is covered in more detail in the terrestrial biodiversity section. Regolith mapping is also available for much of the Rangelands at 1:100,000 scale and is of significant value for understanding ecosystems.

Livestock carrying capacities have been estimated for each land system in pre-European condition. Decreases in carrying capacity as a result of degradation have also been estimated allowing carrying capacities to be estimated in both pre-European and current condition, highlighting land asset change

over time. These descriptions of land system condition can also be used to help calculate other rangeland values such as biodiversity and horticulture, because they are fundamentally descriptions of landscapes, vegetation and soils.

About 520 land systems have been described and mapped (Appendix VI, Attachment 2). For coarser scale planning the land systems have been aggregated to 44 land types (Appendix VI, Attachment 3), such as *"Alluvial plains with acacia shrublands"* or *"Limestone plains with open saltbush and bluebush shrublands and grasslands"*.

For finer scale planning of particular areas, the land systems can be mapped at land unit level (at a scale of tens of metres to several kilometres). Whilst land units have been described for each land system, widespread mapping is not available at land unit level. Land units (at the fine scale) are functionally close to the hydrologic process units described by Tinley (at the coarse scale).

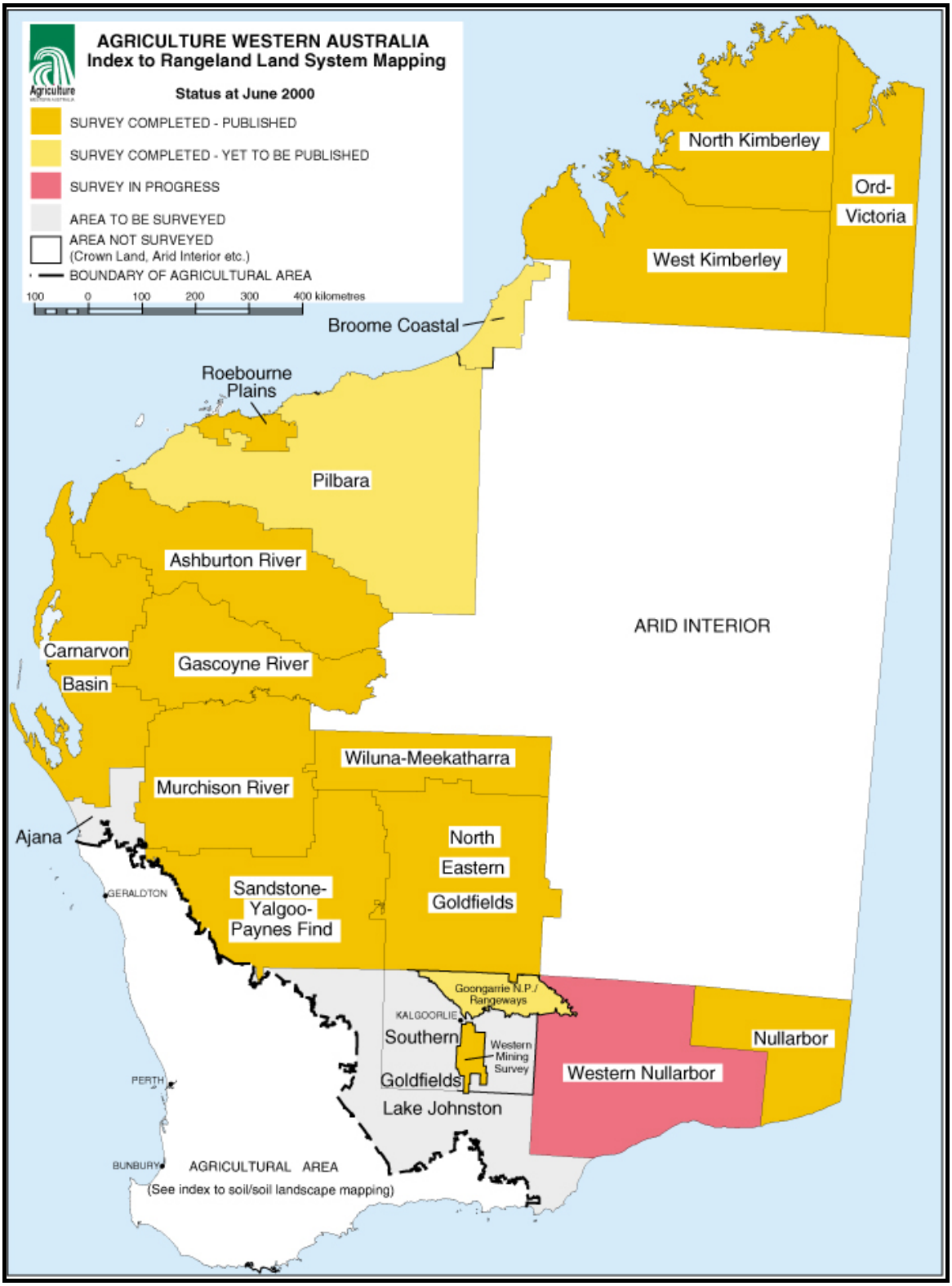


Figure 5: Rangeland Land System Survey Areas

Resource Condition of Pastoral Land Assets

Since the Gascoyne catchment survey of 1969, resource inventory surveys have provided an assessment of pastoral land resource condition (Table 3). These data provide a snapshot of resource condition at the time of survey and are a useful baseline against which current and future range condition can be compared.

The resource condition data show that 46 percent of the resource condition traverses (total sample size of 74,827) were in good condition, 30 percent in fair and 24 percent in poor condition. A little less than one percent of the land was mapped as severely degraded and eroded. Not surprisingly, those areas that are dominated by major drainage basins (eg the Ashburton and Murchison) tend to have less land in good condition and a corresponding increase of land in poor condition, due to their inherent fragility and their early and heavy use by the pastoral industry.

Table 3: Resource Condition Summaries for Regional Rangeland Surveys

Region surveyed (and year commenced)	Total area (km^2)	No. of traverse assessments	Severely degraded and eroded area (as mapped)		Resource condition classes (% of traverse assessments)		
			km^2	%	Good	Fair	Poor
Gascoyne (1969)	63,400	2,426	1,205*	1.9*	32	53	15
West Kimberley (1972)	89,600	4,532	2,000*	2.2*	20	50	30
Eastern Nullarbor (1974)	47,400	1,273	0	0	50	10	40
Ashburton (1976)	93,600	8,608	534	0.6	50	34	16
Carnarvon Basin (1980)	74,500	10,952	647	0.9	45	32	23
Murchison (1985)	88,360	13,441	1,560	1.8	21	37	42
Roebourne Plains (1987)	10,216	1,172	233	2.3	51	27	22
North-eastern Goldfields (1988)	100,570	10,470	452	0.4	39	32	29
Sandstone-Yalgoo-Paynes Find (1992)	94,710	9,435	145	0.2	45	32	23
Pilbara (1995)	181,736	12,518	322	0.2	77	11	12
All areas surveyed	843,576	74,827	7,098	0.8	46	30	24

* Not mapped, estimate only.

From A.M.E. Van Vreeswyk, A.L. Payne, K.A. Leighton and P. Hennig, (in prep.) 'An inventory and condition survey of the Pilbara region of Western Australia', Agriculture Western Australia Technical Bulletin

Results from the Western Australian Rangeland Monitoring System (WARMS), which was installed during the 1990s, and pastoral lease inspections, suggest that there have been improvements in all three pastoral zones (Kimberley, Pilbara and Southern Rangelands) during the last decade (Watson and Thomas 2003, unpublished reports to the Pastoral Lands Board). A more ad hoc collection of old photos and miscellaneous observations (Watson, unpublished) also suggests that there have been improvements in vegetation cover and erosion since at least the 1960s and 1970s.

Notwithstanding these apparent improvements in pastoral conditions, Pringle and Tinley (2003) have pointed out that insidious degradation is on-going (in many areas of the Southern Rangelands at least). The impact of this insidious degradation will be felt gradually, but over very long timescales unless interventions are applied. These observations present a contradiction, the reason for which is that assessments have been made in different parts of the landscape (Pringle *et al*., submitted to Landscape Ecology).

Degradation occurred early – a case study from the Gascoyne-Murchison

Whilst the rangeland surveys have documented degradation across the pastoral Rangelands, history suggests that much of this took place during early development of the pastoral industry. The following case study of the Gascoyne-Murchison region highlights this point. Similar histories can be written for other areas within the pastoral zone, such as the Kimberley, where "*over-exploitation in the early years of settlement led to catastrophic stock losses and a new low base level of productivity*" (Hacker 1982).

Much of the land in the Gascoyne-Murchison was first used for commercial livestock grazing in the ten year period from the mid 1880s to the mid 1890s, although some was not taken up until about 1920. Desertification began early, with reports of severe dust storms by 1889 repeated in subsequent droughts (Fyfe, 1940; Brockman, 1987; Watson, 2002). A severe drought in the mid 1930s prompted the State Government to hold a Royal Commission into various aspects of the pastoral industry (Fyfe, 1940). This was followed in 1969 by a government survey into the condition of the Gascoyne River catchment (Wilcox and McKinnon, 1972) documented as a case study in desertification by Williams *et al*. (1980). Wilcox and McKinnon found serious erosion on 29 percent of sites visited and recommended a total of 941,206 hectares should be removed from grazing. A further 3,315,977 hectares were mapped as degraded with some erosion, requiring remedial use. Only 2,057,496 hectares (mostly in hill or stony mantle country) were assessed to be in acceptable condition. They recommended a reduction in stock numbers of 43 percent.

Severe degradation occurred in the early years of pastoralism. Williams *et al*. (1980) estimated that within the Gascoyne catchment, the number of sheep by 1900 was already 60 percent of the historical peak attained in 1934, and these very high numbers of sheep were carried on very few watering points. For example, Brockman (1987) reported that in 1885 Minilya Station (to the west of the Gascoyne catchment) carried 24,000 sheep but with "… *absolutely no improvements* …" (ie infrastructure such as fences or artificial watering points). In the Gascoyne catchment itself, Williams *et al.* (1980) reported that "… *prior to 1934 one station carried in excess of 100,000 sheep with no more than three wells and shallow soaks opened up in the river bed* …".

These high stock numbers, when combined with severe drought, led to major degradation events (McKeon *et al*., 2004). There is some evidence however, that that the resource was in decline even before these major events, which served to both expose and amplify the background degradation caused by overstocking (Watson *et al*., 2004).

A number of formal enquiries have recognised on-going problems with the pastoral industry, many of them produced by the lowering of the resource base in many areas during the early years of pastoralism settlement. They include the Fyfe Royal Commission (Fyfe, 1940), the Jennings Report (1979), the Select Committee into Land Conservation (House, 1991; House, 1991a) and the Pastoral Wool Industry Taskforce (Anon, 1993).

2.6.3 Major Uses and Values of Land

A broad mix of tenures exist throughout the Rangelands, which are summarised in the map below (Figure). Whilst tenure is predominantly pastoral, conservation or UCL, a range of other uses and values exist within these.

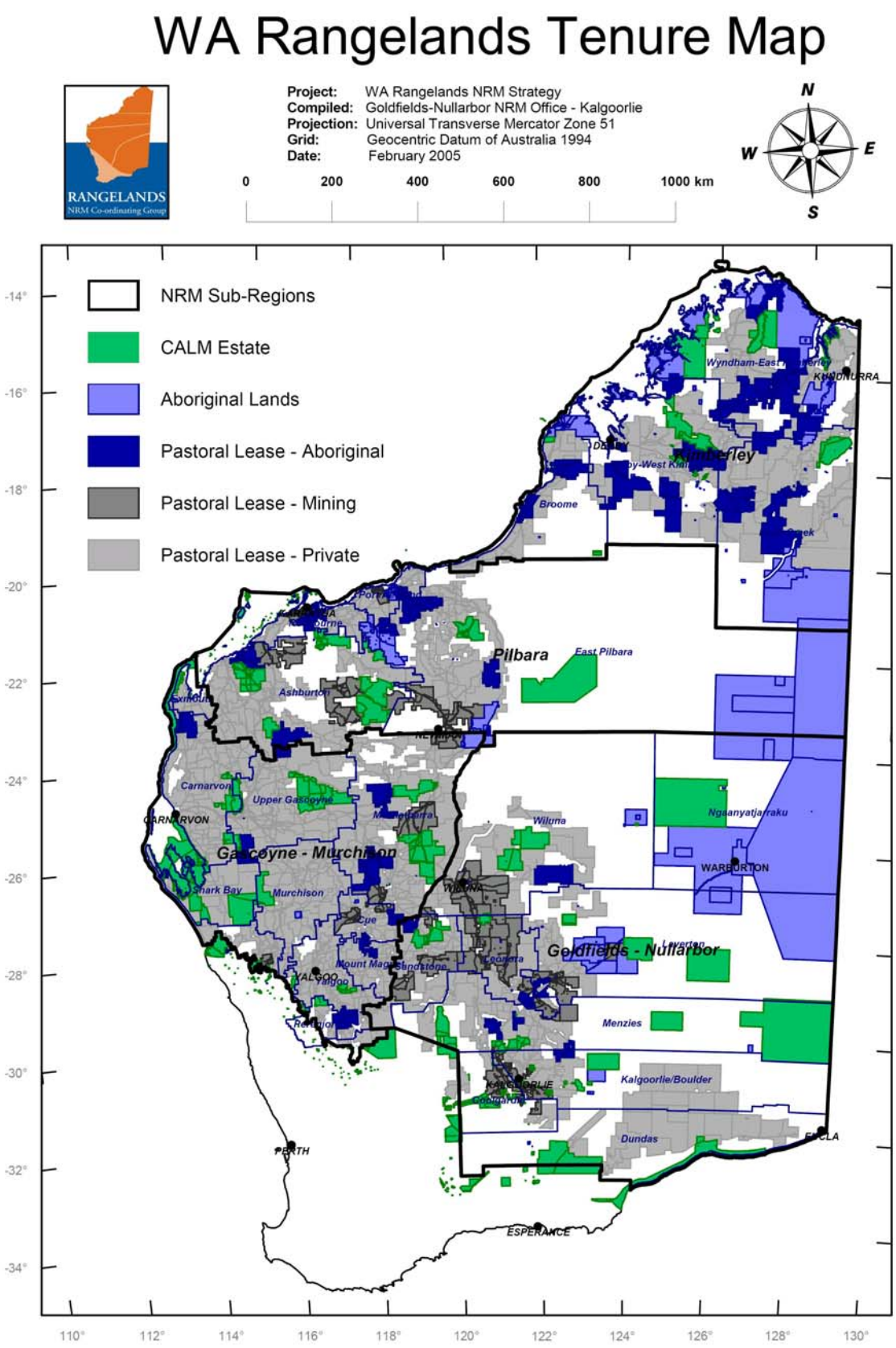


Figure 6: Land Tenure in the Rangelands

Pastoralism

Pastoralism is the most geographically significant land use in the region covering about 45 percent of the Rangelands (and 36 percent of the State). There are 481 pastoral stations made up of 527 pastoral leases throughout Western Australia's Rangelands covering nearly 90 million hectares from the Kimberley in the north to the Great Australian Bight in the south.

Generally speaking a greater proportion of sheep are grazed in the Southern Rangelands and cattle in the Northern Rangelands. Pastoralism is a valuable industry, estimated to be worth nearly $139 million in 1999/ 2000 (Table 4).

Table 4: Gross Value of Pastoral Production by Commodity 1999/ 2000

	Cattle Sales $'000	***Sheep Sales $'000***	***Wool Sales $'000***	***Total Pastoral $'000***
Goldfields	1,564	2,104	7,850	11,518
Gascoyne-Murchison	16,369	6,691	18,871	41,931
Pilbara	22,861	1,385	1,709	25,955
Kimberley	59,152			59,152
TOTAL	**99,946**	**10,180**	**28,430**	**138,556**

As well as the economic value of pastoralism, the industry has contributed to the State's rich cultural heritage and to broader management of the Region. Pastoral communities have made significant contributions to maintaining infrastructure throughout the Rangelands such as roads and airstrips, which provide benefits to other industries such as tourism.

There has been a gradual and increasing trend in the value of pastoral production from the Rangelands, driven mainly from the Kimberley. A small number of pastoralists have also diversified into activities that complement their pastoral enterprises, including nature-based tourism ventures and contracting for mining companies (Department of Agriculture, 2002).

About 49 percent of the 527 pastoral leases are held by families or small family companies (Environmental Protection Authority, 2004). However, an increasing number of leases are held by mining companies (particularly in north-east Goldfields) and Indigenous interests (especially in the Kimberley). Pastoral land tenure is experiencing change generally throughout the region, with recent trends in aggregated pastoral lease areas by management arrangement showing that:

- pastoralists have reduced holdings by 6.5 million hectares;
- Indigenous interests have increased holdings by 2.7 million hectares;
- CALM has increased holdings by four million hectares; and
- mining interests have increased holdings by two million hectares (Department of Agriculture, 2003).

Most of these changes have occurred during the last decade.

All pastoral leases are administered by the Pastoral Lands Board (PLB) under the *Land Administration Act, 1998*, with most leases due to expire in 2015. Lease conditions require that the land is managed to ensure conservation and regeneration of vegetation (Burnside *et al*., 1995, p 124) and the Board requires that all pastoral leases are maintained as *bona fide* pastoral operations.

Irrigated Plant Industries

The region's land assets also support two major horticultural areas – the Carnarvon horticultural precinct in the Gascoyne and the horticultural development of the Ord River Irrigation Area in the Kimberley. Horticulture in the Gascoyne-Murchison takes place almost entirely along the banks of the Gascoyne River at Carnarvon. It covers an area of approximately 1,500 hectares and relies on irrigation from

aquifers associated with the Gascoyne River and its alluvial soils (Gascoyne Development Commission, 2003).

In the Ord River Irrigation Area, large areas near Kununurra are devoted to horticulture and rely on fertile alluvial soils and irrigation from Lake Argyle. The horticulture industries at Carnarvon and Kununurra capitalise on out-of-season markets in southern Australia and emerging international markets, generating in excess of $90 million per year (Environmental Protection Authority, 2004).

Tourism

Western Australia's Rangelands present some exceptional opportunities for people seeking outback experiences and it attracts people from throughout Australia and around the world. Essentially, tourism in the region is based on the beautiful and unique natural resource assets of the region, particularly landscape icons such as Mount Augustus in the Gascoyne-Murchison, Karijini and Millstream Chichester National Parks in the Pilbara, and coastal sites such as Ningaloo Reef and Broome. There is also a steady increase in the number of recreational four wheel drive enthusiasts accessing remote areas such as on the Canning Stock Route, the Gascoyne Murchison Outback Pathways and Gibb River Road amongst others. The increasing number of tourists seeking outback and northern Australian experiences could place pressure on the region's land assets, and tourists and tour operators need to be aware of their potential impact.

Tourism in the Rangelands is enhanced by the region's cultural heritage and history, with increasing numbers of people interested in the State's Aboriginal heritage, and more recent inland history following white settlement and the establishment of pastoral, fishing and mining operations. Specific tourist attractions have been established to exploit this interest such as the Outback Pathways initiative in the Gascoyne-Murchison, Golden Quest Heritage Trail in the Goldfields and the Ibis aerial highway in the Kimberley.

The value of tourism in the Rangelands is difficult to estimate, because of the relationship between actual expenditure (which can be measured), and flow-on or multiplier effects of that expenditure (which can't be measured). Tourism Western Australia figures suggest that tourism expenditure in each of the sub-regions for 2003/ 2004 was more than $170 million, and was as high as $380 million in the Goldfields-Nullarbor (although this figure includes the Shires of Esperance and Ravensthorpe). The Ningaloo/ Cape Range area alone brings in $127 million a year. The value of tourism throughout Western Australia is calculated to be approximately 3.5 percent of Gross State Product, and this figure can be assumed to be reasonably constant across all regions (Tourism Western Australia, 2005).

Tourism by its nature causes its economic impact to vary widely across regions, depending on the location of attractions. Tourism is becoming increasingly important for the long-term viability of many regional communities. In 2004, there were 587,000 international visitors and 6.5 million overnight domestic visitors to Western Australia, with a combined expenditure of $4.2 billion. Western Australia's first Tourism Satellite Account estimates that in 2001/ 2002, 54,000 jobs were directly related to the State's tourism industry, with a further 18,000 jobs indirectly related tourism (Access Economics, 2003).

The Western Australian Tourism Commission has regionalised the State into five tourism regions. The approximate definition and coverage of the zones are:

- Orange zone – Perth and surrounds including Mandurah and Northam;
- Green zone – south west including Bunbury, Albany and Margaret River;
- Blue zone – west coast strip about 150 kilometres wide from north of Perth to Exmouth, including Geraldton and Carnarvon;
- Red zone – north including Pilbara, Kimberley and all inland areas north of Newman; and
- Yellow zone – the rest, including Kalgoorlie, Esperance, Narrogin and Merredin.

All of the Red zone and part of the Blue and Yellow zones are in the Rangelands NRM region. The expenditure of visitors in these three Tourism zones in 2001/ 2002 was approximately $1.29 billion

dollars. In total there were approximately two million visitors who stayed for a total of 12.8 million bed nights on average in 2003 and 2004 (Access Economics, 2003).

More specific information on the significance of tourism in each sub-region can be found in Appendix 1.

Minerals and Petroleum

The Rangelands' onshore land assets includes deposits of iron ore, gold, nickel-cobalt, diamond, base metals, salt, tantalum-tin, manganese, chromite, gypsum, silver, talc, vanadium, heavy minerals, feldspar, gemstones, platinum group metals, bauxite and coal.

Oil and natural gas are produced offshore and are processed at onshore facilities. Petroleum and mineral production from the Rangelands area was valued at $22 billion in the financial year 2003/ 2004 and accounted for approximately 60 percent of the State's exports and 20 percent of gross State product. Oil and gas production from the Pilbara alone during 2003/ 2004 totalled $9.1billion and the industry employed about 25,000 people. Most production was from the North West Shelf Venture's gas fields situated 130 kilometres off the Pilbara coast. The oil and natural gas are piped onshore to the Burrup Peninsula for treatment. Most of the natural gas is liquefied and the liquefied natural gas (LNG) is exported. Gas is also piped along the Dampier to Bunbury Natural Gas Pipeline for use in the Pilbara, Carnarvon, Geraldton, Perth and Bunbury areas and the Dampier to Kalgoorlie and Esperance Natural Gas pipeline. Oil and gas for domestic consumption was also produced by ChevronTexaco, Eni, BHP Billiton, Apache and Mobil at other locations off the Pilbara and Gascoyne coast and on Barrow Island. Production is planned from the Gorgon gas project where an agreement has been negotiated to supply China with 100 million tonnes of LNG worth up to A$30 billion, with treatment of the natural gas proposed to take place on Barrow Island. If this deal goes ahead, it will represent Australia's largest single export and highlights the enormous economic potential of the vast natural gas reserves off the northwest coast of Western Australia.

There are also significant oil and natural gas resources off the Kimberley coast in the Browse and Bonaparte Basins and gas onshore in the Canning Basin at Stokes Bay. Woodside has announced that it plans to produce LNG onshore from the Browse Basin gas. Gas from the Black Tip gas field in the Bonaparte Gulf will be piped to the Northern Territory whilst gas from Stokes Bay will be transported to mining projects in the Kimberley for power generation.

Iron ore production from the Rangelands area during 2003/ 2004 totalled 198 million tonnes, was valued at $5.2billion and employed about 12,000 people. Ninety nine percent of this production was from the Pilbara sub-region with small amounts from Cockatoo Island in the Kimberley and Tallering Peak in the Gascoyne-Murchison sub-region. Currently, the three main producers in the Pilbara sub-region are Hamersley Iron Pty Ltd, BHP Iron Ore Ltd and Robe River Mining Co. Pty Ltd. Fortescue Metals, Hope Downs Ltd and Mineralogy Pty Ltd have major projects on the drawing board in the Pilbara sub-region. Production from Weld Range in the Gascoyne-Murchison sub-region and Koolan Island in the Kimberley sub-region is also planned.

Gold production from the Rangelands area during 2003/ 2004 totalled 5.5 million ounces (170t), was valued at $3.0billion and employed about 13,000 people. Approximately 86 percent of this gold production was from the Goldfields-Nullarbor sub-region with the largest producers being the Super Pit at Kalgoorlie, St Ives, Sunrise Dam, Plutonic, Jundee-Nimary, Paddington, Granny Smith, Kanowna Belle, and Agnew. Most of the remaining 14 percent of gold production was from the Gascoyne-Murchison sub-region with Hill 50 being the major producer. Future significant production from the Gascoyne-Murchison sub-region can be expected from the Burnakura mine and the Fortnum project. The Telfer mine in the Pilbara sub-region (one of the State's biggest mines) recommenced production in November 2004 and is expected to have an annual production of 800,000 ounces of gold and 30,000 tonnes of copper during the next 20 years. The Coyote deposit in the Kimberley sub-region is currently being evaluated.

Nickel concentrates and nickel metal produced from the Rangelands area during 2003/ 2004 were valued at $3.0 billion with an additional $230 million from cobalt and $7 million from platinum group metals produced as by-products of nickel mining. The nickel industry employed about 5,800 people during this period. This production was entirely from mines in the Goldfields-Nullarbor sub-region with the largest producers being Kambalda, Mount Keith, Leinster, Murrin Murrin, Cosmos, Miitel-Wannaway and Black Swan. Other significant nickel projects in the Goldfields-Nullarbor sub-region are Emily Anne, Maggie Hay, Long-Victor and Teutonic. In the Kimberley sub-region, the Sally Malay mine commenced production in September 2004 and there is significant nickel-copper mineralization at the nearby Copernicus prospect. In the Pilbara sub-region, nickel has been mined from Radio Hill and there are deposits at Mt Sholl, Ruth Well and Sherlock Bay.

Diamond production from the Rangelands area during 2003/ 2004 totalled 32.5 million cubic tonnes, was valued at $520 million and employed about 1,200 people. This production came entirely from the Kimberley sub-region with Argyle producing 99.8 percent of the volume and 97.1 percent of the value, with Ellendale producing the remainder. Production at Ellendale is expected to increase to 700,000 cubic tonnes per year in 2006.

Base metal (copper, lead and zinc) production from the Rangelands area during 2003/ 2004 was valued at $246 million and employed about 900 people. Major producers were the Lennard Shelf (zinc–lead) in the Kimberley sub-region, Golden Grove (copper–lead–zinc) in the Gascoyne-Murchison sub-region and Nifty (copper) in the Pilbara sub-region. The Lennard Shelf ceased production in early 2004 but prior to that was the world's sixth largest zinc producer. A significant resource remains in the Lennard Shelf area and this is currently being re-evaluated. Lead production from the Magellan mine in the Goldfields-Nullarbor sub-region commenced in January 2005.

Salt production from the Rangelands area during 2003/ 2004 totalled 9.8 million tonnes, was valued at $173 million and employed about 660 people. Approximately 75perncet of the salt was produced from the Pilbara and 25 percent from the Gascoyne-Murchison.

Tantalum and tin production from the Rangelands during 2003/ 2004 was valued at approximately $80 million and came from Wodgina in the Pilbara sub-region. There is also a tantalum deposit at Bald Hill in the Goldfields-Nullarbor sub-region. Manganese production from the Rangelands area during 2003/ 2004 totalled 600,000 tonnes, was valued at $80 million and employed about 150 people. This production was entirely from Consolidated Minerals' Woodie Woodie operations in the Pilbara sub-region. Chromite valued at $26 million and gypsum valued at $20 million were produced from the Rangelands area during 2003/ 2004. Silver, vanadium, talc, gem and semi-precious stones and feldspar were also produced.

There are significant undeveloped deposits of bauxite, coal and rare-earths in the Kimberley sub-region, uranium in the Pilbara sub-region and uranium, phosphate and rare-earth deposits in the Goldfields-Nullarbor sub-region. If an LNG plant is built in the Kimberley, the Mitchell Plateau bauxite and other undeveloped deposits in the Kimberley could become economic to develop.

Conservation

The biodiversity of the Rangelands, including its physical components, contributes to ecosystem resilience and thereby underpins the stability and resources of all sustainable industries, particularly the pastoral and the tourism industries. Biodiversity provides "ecosystem services" in the form of clean air and water, fertile soils, nutrient and carbon cycling, food sources and functioning landscape processes. These values are often not well recognised or accounted for as they are in the most case intangible in terms of economic value. However, it can be seen from examples world wide that environmental and biological degradation ultimately leads to decreased long term sustainability. It is therefore not only important to conserve biodiversity for ethical reasons but also to maintain viable and functioning landscape systems.

The Rangelands holds important landform and biodiversity conservation values and more than 19 million hectares are managed for conservation including marine reserves, national parks, nature reserves, state forests, other reserves and UCL to be converted to conservation reserve, by CALM. Examples of these values include vast vegetated landscapes that are largely intact and free from broad-scale clearing, significant populations of native fauna and flora species with high levels of endemism, internationally recognised geological and biological subterranean features such as karst systems and troglofauna, not to mention coastal and marine biodiversity assets, which are often influenced by terrestrial processes. Landforms are also an important element for conservation of visual amenity and habitat values.

The State's formal reserve system is the cornerstone of national strategies for protecting and maintaining biodiversity assets. However, throughout the Rangelands it does not yet meet the requirements for a Comprehensive, Adequate and Representative Reserves System. It must be recognised that significant conservation values in the Rangelands exist outside the formal reserve system on UCL, Aboriginal, pastoral and other lands that are equally in need of protection. Consequently an integrated and holistic effort is required to conserve biodiversity values. A detailed outline of the biodiversity conservation values of the Rangelands' landscapes is provided in the section 2.6.7 on terrestrial biodiversity assets.

Traditional Land Use and Management

Indigenous people attach particular values to, and are owners of significant land assets in the Rangelands (Figure 7).

For example, 30 percent of the pastoral stations in the Kimberley are managed by Indigenous people. Indigenous pastoral stations are not only commercial businesses, but also home to communities, with the land serving a range of cultural uses and non-commercial, economic activities ncluding:

- hunting, fishing and gathering;
- building and using shelter;
- digging for and using stone, ochres and minerals;
- caring for country through spiritual obligations, environmental requirements and harvesting produce; and
- sharing and exchanging resources derived from country.

Each of these derives from specific social and cultural obligations Aboriginal people have to themselves and country.

Issues

A large part of Western Australia's Rangelands is managed by, or on behalf of Aboriginal people under various forms of Crown land tenure, principally Aboriginal Reserve and pastoral lease. Almost all of the Rangelands is also the subject of applications for determination of native title and there are significant areas where native title has already been determined to exist. Both Crown tenure and native title imply significant rights and responsibilities for NRM on the part of the titleholders.

Aboriginal people have a unique collective experience that derives from their disadvantaged minority status following European settlement. The State's Indigenous population manifests poverty, poor health, high rates of mortality for age and high incarceration rates, amongst many other indicators of significant economic and social disadvantage relative to every other sector of the Western Australian community.

State and Commonwealth Governments have attempted to deal with Indigenous disadvantage in a variety of ways. Over the last thirty years governments have restored land to Aboriginal people and have made grants of land-based enterprises, especially pastoral businesses, to Aboriginal groups.

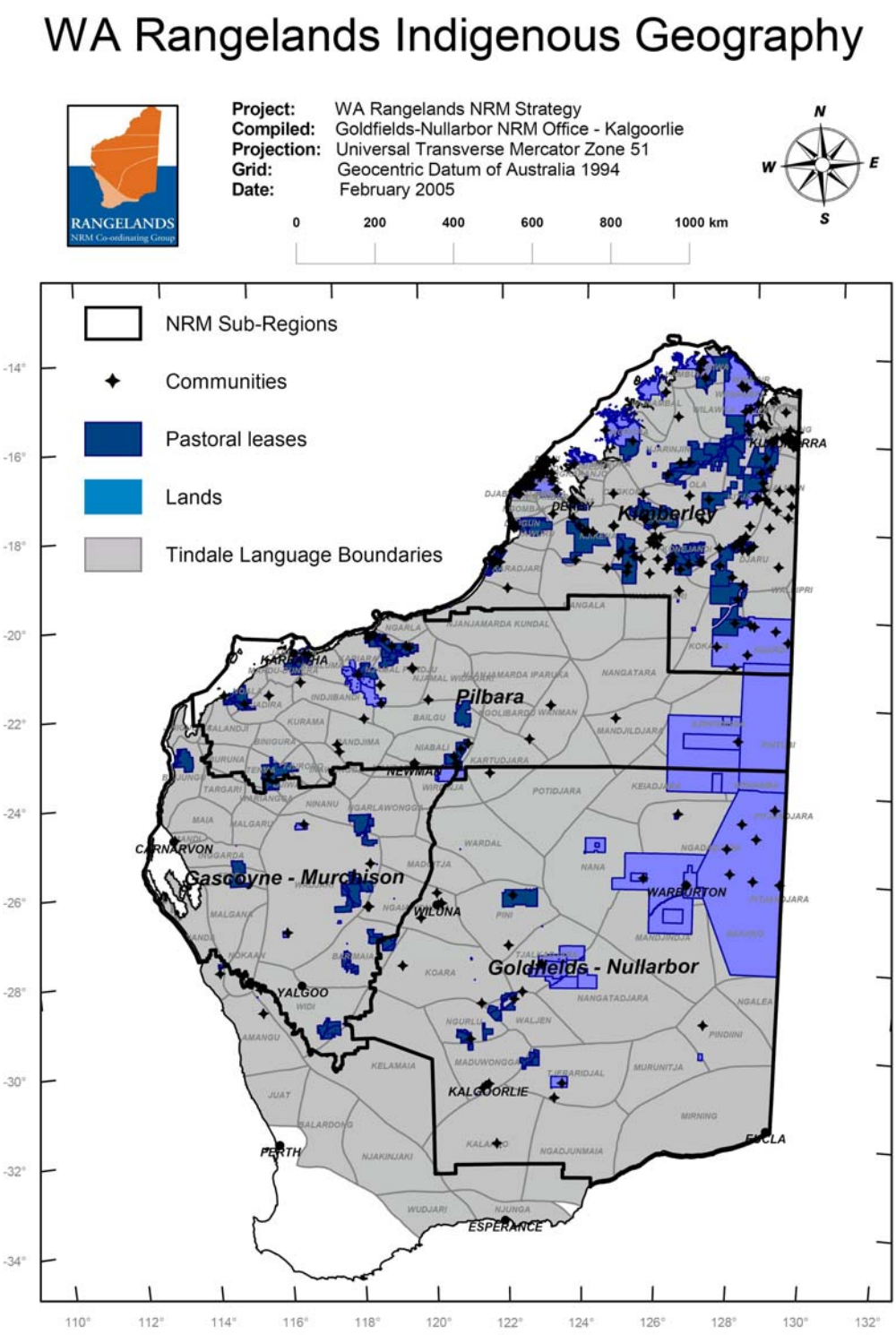


Figure 7: Indigenous Geography in the Rangelands

Governments have also recognised on-going Indigenous connection to land and natural resources in a number of other ways, including since the mid nineteenth century by statutory provisions intended to enable access to the natural resources associated with pastoral leases. In more recent times, governments have promoted the development of joint management arrangements for lands in the conservation estate and the facilitation of agreements with other landholders (especially pastoralists) to enhance the access of Aboriginal people to all Crown lands.

NRM can help to identify the management and planning needs that arise from Aboriginal people's contemporary ownership or use of the Region's natural resources. However, in doing so it recognises that Indigenous peoples' contemporary land uses, aspirations and legally protected interests derive in large part from pre-colonial patterns of land ownership. Unique knowledge, interests and concerns regarding the use of land and waters are preserved and transmitted within the Indigenous community. NRM issues will arise in the implementation of the strategy that are not based solely on the ownership or use of the specific lands held by Aboriginal people under the formal tenure system or as recognised by native title determinations. Such issues will also concern contemporary relationships between the Indigenous and non-Indigenous community, the management requirements of land-based industries such as pastoralism and mining and the broader public interest in the protection and enhancement of biodiversity and other values in the landscape.

Opportunities

In the Rangelands, particularly in the Kimberley, there are a growing number of community based initiatives in NRM, particularly for the management of wildfire, invasive weeds and feral animals. Such services, which are essentially of a broad community service character, are most readily and appropriately provided by Indigenous people resident on their traditional lands and could be funded accordingly. There is the opportunity for significant public funds currently disbursed through the Community Development Employment Program to be redirected though Commonwealth – State transfer mechanisms to State land management agencies or community based sub contractors.

These initiatives if fully developed could provide a genuine and important service to the wider Australian community in the management of natural resources and simultaneously offer significant opportunities for the creation of meaningful Indigenous employment in remote areas.

The Rangelands NRM Strategy and Investment Plans can provide an opportunity to capitalise upon these initiatives and leverage funds available under other State and Commonwealth programs.

Strategy Development, Implementation and Review

The Strategy has begun to tap the representative capacity of common-interest organisations, local government and industry groups in the Rangelands, filtering and synthesising community-held knowledge and opinion. Because of the identified need to take account of both traditional and contemporary concerns and interests in the social and cultural as well as economic domain, these matters may best be determined by reference to the replacement structures for the Aboriginal and Torres Strait Islander Commmission (ATSIC) Regional Councils, native title working groups, and other appropriate Aboroginal organisations.

The Rangelands NRM Co-ordinating Group is also keen to work through emerging national policy inititiatives for improved service delivery to Indigenous communities. In particular the Group acknowledges the opportunities presented by Regional Partnership Agtreements (RPAs) and Shared Responsibility Agreements (SRAs) through which NRM resources can be delivered along with a number of other funding programs.

Regional Partnership Agreements (RPAs)

Regional Partnership Agreements provide a mechanism for guiding a coherent government intervention strategy across a region, eliminating overlaps or gaps, and promoting coordination to meet identified priorities for the region.

Shared Responsibility Agreements (SRAs)

Shared Responsibility Agreements (SRAs) are more detailed documents operating at a family or community level. SRAs will set out clearly what the family, community and government is responsible for

contributing to a particular activity, what outcomes are to be achieved, and the agreed milestones. http://www.oipc.gov.au/About_OIPC/new_arrangements/IndigenousRepresentation.asp

A more detailed outline of Indigenous land use and NRM issues is provided at Appendix VII, including a map of Indgenous owned and managed lands throughout the Region.

Unallocated Crown Land and Unmanaged Reserves

Within the Rangelands NRM region, over 80 million hectares of land occurs on UCL, UMRs and other Crown lands. The major values of UCL and UMRs are not well documented with few if any surveys and audits undertaken on each parcel. More than 50 percent of Rangelands UCL occurs in the arid region and is generally only accessed by outback adventurers, mining companies and some Aboriginal communities. Whilst there is a lack of information on UCL and UMRs, there is likely to be significant conservation values as evidenced through recent biological surveys and consultancy reports (these are highlighted in the terrestrial and aquatic biodiversity sections following). In some cases the values are not subject to the same level of threat from particular land uses but this is not always the case.

Aboriginal people have been recognised as having special rights to use UCL for traditional purposes and values such as hunting and gathering and cultural ceremonies. It is important that Aboriginal people are able to continue to have access to UCL to retain and pass on cultural heritage.

Other Crown land includes road and rail reserves, shire reserves, Commonwealth held lands and lands held by the Defence Department. There a number of values associated with these lands including maintenance of infrastructure and protection from threatening processes such as erosion and fire.

Opportunities for Diversification

The Rangelands land assets provide significant opportunities for diversification, particularly on pastoral leasehold land. A number of these opportunities were pursued through the GMS and continue to be priorities for public and private investment in the region. Inland horticulture, for example, has significant potential and a number of opportunities are being investigated throughout the region. Additionally, a number of stations, particularly in the Gascoyne, are examining the use of artesian water to support aquaculture. Eco-tourism is another potential, alternative use of land assets in the Rangelands. A number of pastoralists and Aboriginal communities are investigating opportunities for diversification into eco-tourism.

The potential for diversification to have a significant impact in the region is demonstrated by the intensive plant industries that have been developed at Wooramel and near Wiluna. In these cases where there has been suitable irrigation water available, horticultural crops, such as table grapes and asparagus, have been grown and sold to markets in Perth. In the West Kimberley near Broome and Fitzroy Crossing, irrigated crops such as sweet potatoes and melons have also been produced successfully. The Department of Agriculture has also been approached for advice on a wide range of crops from irrigated pasture to dates.

The key to further development is a better understanding of the climate and availability of natural resources in the region. There are currently studies under way to assess potential water resources. The need for better climatic data, that enable crops to be evaluated for suitability against climate, will be critical in assessing future opportunities.

An approach that has been used in other regions is to workshop opportunities and then undertake desktop analysis to rank crops for their production, scale of production and market potential. The ranking enables a focus on the opportunities that are most likely to be successful. Consideration of these opportunities must, however, also extend to the relevant environmental risks. For example, date palms have the capacity to become environmental weeds, and have done so in many parts of the region.

2.6.4 Major Threats to Land

The areas of the Rangelands considered to be subject to the greatest threats are the border area between the intensive and extensive land use zones, the coastal area of the Geraldton Sandplains bioregion, coastal Carnarvon and Pilbara and inland Gascoyne and Murchison bioregions, where the major impacts are damage to native vegetation and a loss of topsoil. By far the most significant pressure in these hot spots is unsustainable grazing. Along with inappropriate fire management, poor water and soil management practices, weeds and feral animals, it has resulted in land degradation and biodiversity loss as well as a consequent reduction in natural and primary productivity (Environmental Protection Authority, 2004). It should be noted, however, that if the current trend of increasing fire continues, the Kimberley may become the most severely degraded part of the Rangelands within the next 20 to 50 years. Furthermore, maintaining communities in the Rangelands influences land condition as roads and other infrastructure often alter the natural hydrology of the land.

Excessive Grazing Pressure

As mentioned above, the major threat to land assets in the Rangelands is unsustainable grazing, or the occurrence of more animals in the landscape than the assets can support. This includes domestic animals such as sheep, horses and cattle, and unmanaged herbivores such as camels, goats and donkeys which also place significant grazing pressure on the land. Kangaroos can also contribute significantly to the total grazing pressure, although this is more of an issue in the southern Rangelands than the Kimberley. For example, in 1990 it was estimated that one million goats were present in the arid shrublands, contributing 12 percent of the total grazing pressure. At the same time kangaroos exerted half the grazing pressure, whilst sheep only provided 38 percent (Burnside *et al*., 1995, p 125). Not surprisingly then, one of the major NRM challenges in the region is management and control of total grazing pressure.

Most often, grazing pressure is highest in those parts of the Rangelands where water occurs, from either natural or artificial sources. Riparian areas that offer natural water sources also have soils that are susceptible to erosion. This compounds the impact of domestic and non-domestic animals in these areas. Artificial water sources have also been installed in the Rangelands to support domestic animals, concentrating grazing pressure in particular areas. These artificial water sources also attract non-domestic herbivores, which together with domestic stock can cause soil erosion, damage to native vegetation and spead weeds.

As well as excessive grazing pressure, inappropriate grazing management can threaten land assets. Not de-stocking in times of drought, or re-stocking immediately following a drought before the vegetation has a chance to recover, can result in declining rangeland condition through erosion and vegetation decline. This also has an impact on soil health with studies showing that where vegetated patches are denuded the soil loses critical nutrients, infiltration rates decline and biological activity is adversely affected (Tongway and Ludwig, 1994).

However, removing or reducing grazing pressure or adopting alternative grazing strategies will not necessarily result in an improvement of land condition. This is because landscape patterns and processes constantly change and, if damage to these systems crosses thresholds that exceed the capacity for self-repair, processes will be permanently altered (Whisenant, 1999). For example, where grazing has greatly reduced the amount of ground cover in an area, surface flow characteristics and nutrient cycle will be altered. This results in water leaving the landscape with a greater velocity, giving it the energy to scour and incise drainage lines, and take vital nutrients with it. Incised drainage requires active intervention, not just grazing pressure adjustments, to restore natural flows, ultimately keeping water on the landscape longer to increase infiltration capacities.

Catchment-wide impacts of degradation initiate biophysical processes in the landscape that cause catchment leakage. Pringle and Tinley (2003) highlight that these impacts cannot be reversed by simply using mechanical interventions at locations showing the worst effects. It requires mechanisms that slow and calm the movement of water at strategic locations throughout the catchment or landscape,

consequently reducing the effects of erosion. Depending on the degree of catchment dysfunction, restorative mechanisms may take considerable time to reverse degrading processes in a landscape. Hence, management focus is on the cause of the degradation not the symptom. This applies throughout the Rangelands.

Weeds Affecting Land Management

Weed infestations occur through accidental introductions or intentional introductions for commercial purposes. They are able to establish in the landscape through a number of possible vectors, such as machinery or livestock, and a lack of adequate preventative and control measures. Weed infestations lead to a loss of biodiversity by out competing native species for space and resources. This then leads to a loss of land area from which production is derived, or to a general lowering of production from a given land area (or both), and this in turn is likely to increase grazing pressure on other parts of the landscape (Fisher *et al*., 2004).

Major weed infestations in the Rangelands include Noogoora Burr in the Fitzroy and Ord Rivers in the Kimberley, and Mesquite and Parkinsonia infestations in the Kimberley, Pilbara and the Gascoyne River and its tributaries. Whilst in the Goldfields a number of weed species have been identified, eight of which have been declared under the *Agriculture and Related Resource Protection Act 1976*.

Early intervention is always more effective than delayed action when it comes to controlling the population and spread of weed species. Part of regional planning should be to identify nascent weed infestations and alert land managers in the region to the need for timely and concerted action to protect land assets from potential degradation (Fisher *et al*., 2004).

Further discussions on the impact of weeds, especially environmental weeds (those of greater concern to biodiversity than production), can be found in the Terrestrial Biodiveristy Section 2.6.10.

Altered Fire Regimes

Altered and inappropriate fire regimes are a major threat to land assets in the Rangelands. Fire is an integral part of rangeland management and has shaped much of the vegetation and ecology of the Region. The frequency of fires used by Indigenous people to hunt and manage vegetation probably changed vegetation types (for example, open savanna replaced open forest).

The National Land and Water Resources Audit found that frequent fires and fires late in the dry seasons are the most damaging in the Kimberley. The area burnt in the Kimberley has increased every year since monitoring began, from 5,000,000 hectares in 1994 to 25,000,000 hectares in 1998 (Environmental Protection Authority, 2004). The effects of these frequent late, dry season fires on populations of plants and animals is now seen as having a major impact on biodiversity and sustainable land management (Palmer *et al*., 2002). Fire management is usually inextricably linked with grazing management (Fisher *et al*., 2004).

In the Goldfields-Nullarbor, Gascoyne-Murchison and Pilbara, the spinifex or hummock grassland areas are most impacted by altered fire regimes. These areas would have been patch burnt in a deliberate and skilful manner by Traditional Owners. The environment had most probably adapted to this regime over a long period of time and this would have reduced the risk of large wildfires. Without this, large wildfires, started most often by lightening, can have a devastating effect over very large areas. This has a large impact on both plant and animal populations in the Region and results in a much more homogeneous landscape. Lack of resources is a key constraint to best practice fire management at present in these vast and often remote areas and more research is needed to determine the most ecologically appropriate fire regimes. CALM is planning to work in partnership with Indigenous communities to strategically burn every couple of years on UCL and CALM reserves to produce a more heterogeneous landscape and reduce this impact in the spinifex areas. Other areas outside the spinifex zone may be negatively impacted by a rarity of fires, if they contain fire-dependent species.

Fires are also used by some land managers as a management tool but at present this is relatively uncommon and uncoordinated, and its impact on biodiversity and land condition unknown. A coordinated approach to fire management throughout the Region involving all stakeholders is needed.

Unmanaged Tourism and Recreation

Unmanaged tourism and recreation can pose a threat to land assets in the Rangelands. The impact on the environment varies depending on the availability of access to areas, visitor pressures and attractions.

Unmanaged and uncontrolled recreational camping and access by off-road vehicles can cause vegetation degradation, loss of aesthetic value and increased erosion. Other adverse impacts include litter, oil spills, translocation of non-endemic species and the introduction of weeds. In addition, damage by tourists to significant sites such as caves and the material they can contain can be of concern to Traditional Owners. Lack of signage, formalised camp sites and the feasibility of providing effective enforcement and regulation is a major impediment to sustainable tourism and recreation.

Other adverse impacts include loss of visitor experience resulting from competition for resources, loss of aesthetics, overcrowding and incompatible recreational and tourism activities. A large part of the attraction of tourism to the Rangelands coast is the opportunity to explore a relatively pristine area and experience the remote feeling of wilderness. Over development and excess tourist numbers could threaten visitor experiences and the environment, and must be managed accordingly.

It is important that tourism in the Region is well managed according to local and State Government requirements, and possibly through appropriate codes for practice.

Mining and Heavy Industries

Mining activity causes localised impacts on land formation and vegetation cover, and loss of habitat directly at mine site. These voids in the landscape are sometimes highly visible and hence, also have direct impacts on the aesthetic values of Region. There can also be further impacts from associated road and rail infrastructure crossing flat terrain and rivers, which alters hydrology causing drainage shadows and ponding.

Mining and heavy industries may also cause pollution threats such as saline intrusion into ground water, inappropriate disposal of mine tailings, chemical spills and accumulations, and burning of fossil fuels at petrochemical plants causing acidification of the environment.

Impacts on riparian vegetation from altered hydrology due to groundwater extraction and discharge of excess water into rivers are addressed in the waterscape section.

2.6.5 Current Management of Land

Managing Total Grazing Pressure in the Pastoral Rangelands

A fundamental management issue throughout the Region's pastoral areas is matching animal (livestock, feral and native) numbers to land capability in the medium to long term and to feed availability in the short to medium term. High variability in rainfall means that it is not possible to settle on a single, static carrying capacity. Critical components of this short, medium and long term matching of animals to resource include the timing, length and spatial distribution of grazing, with management for drought (ie before, during and immediately following drought) of special importance. Managers who develop their own station-wide management strategy, with adaptations for different landscapes at different times, have the best opportunity of preventing degradation and promoting rehabilitation (Watson, 2003). Many pastoralists are already investing considerable time and money into improved land management practices which has contributed to improved range condition. This strategy should be part of, and integrated into, station business planning where grazing management decisions essentially become key business management decisions.

Controlling the spatial distribution, intensity and timing of grazing pressure is one of the most important management activities for preventing degradation and encouraging rehabilitation. Traditionally, permanent post and wire fencing has been used to control animals and almost all stations have several hundred to a thousand kilometres of fencing. However, the high cost of maintenance and lack of labour has meant that much of this infrastructure has been allowed to deteriorate. Grazing control is now often achieved through the control of watering points (Watson, 2003).

This is firstly through watering point distribution and secondly through controlled access to water. The area around permanent water (up to five to eight kilometres depending on stock type) is more heavily grazed than areas remote from water. Therefore watering point distribution is a critical determinant of grazing pressure. Temporary respite from grazing can also be achieved simply by turning waters off. More recently, many pastoralists have been supported by the Gascoyne-Murchison Strategy (GMS) to build total grazing management (TGM) yards around permanent waters. These yards use a trapping system to control entry of livestock and feral animals to water, also allowing animals to be gathered together without expensive mustering. They also have the potential to address the major and on-going issue of uncontrolled grazing by goats and kangaroos (Watson, 2003). In conjunction with land systems fencing and improved water distribution, some eight million hectares of the Gascoyne-Murchison are benefiting from the approximately 1,000 TGM systems that have been installed under the GMS. These systems could be extended throughout the region to provide similar benefits.

Rangeland Monitoring on Pastoral Lands

Monitoring Rangelands is also a key activity for improving knowledge about the change in condition of land assets. This is undertaken through the Western Australian Rangeland Monitoring System (WARMS), which consists of a set of approximately 1,600 ground based, permanent monitoring sites (Figure 8). Their location is designed to be representative of the pastoral Rangelands as a whole as well as representative of those areas where much of the livestock grazing occurs. For example, about 57 percent of sites are between two and four kilometres from permanent water. Data collection includes the assessment of perennial vegetation and landscape function. There are two types of sites:

1. grassland sites, which are used in the Kimberley and much of the Pilbara where grasslands dominate; and
2. shrubland sites, which are used in the Southern Rangelands and southern Pilbara.

Kimberley sites are reassessed on a three year cycle, whilst Pilbara and Southern Rangelands sites are reassessed on a five to six year cycle. Although each lease larger than about 50,000 hectares has at least one WARMS site, the system was designed to report at a regional or vegetation type scale, rather than at a station scale.

The stratification used to locate WARMS sites was based on an index of asset value and risk of degradation. Major vegetation groups were aggregated to 16 “WARMS groups” and the areal extent of each group, combined with its productivity (for pastoral purposes) and fragility were used to derive an index for *pro rata* allocation of sites. Vegetation groups that were both productive and fragile (eg chenopod shrublands) received proportionally more sites than vegetation groups that were unproductive and robust (eg hard spinifex).

Additionally the State’s resource condition and inventory surveys provide a comprehensive baseline for a monitoring framework. They describe land systems, vegetation types and land units in pre-development (“pristine”) form as well as following various forms of degradation. This provides not only a catalogue and mapping basis for the monitoring framework, but also sets of benchmarks for land asset values.

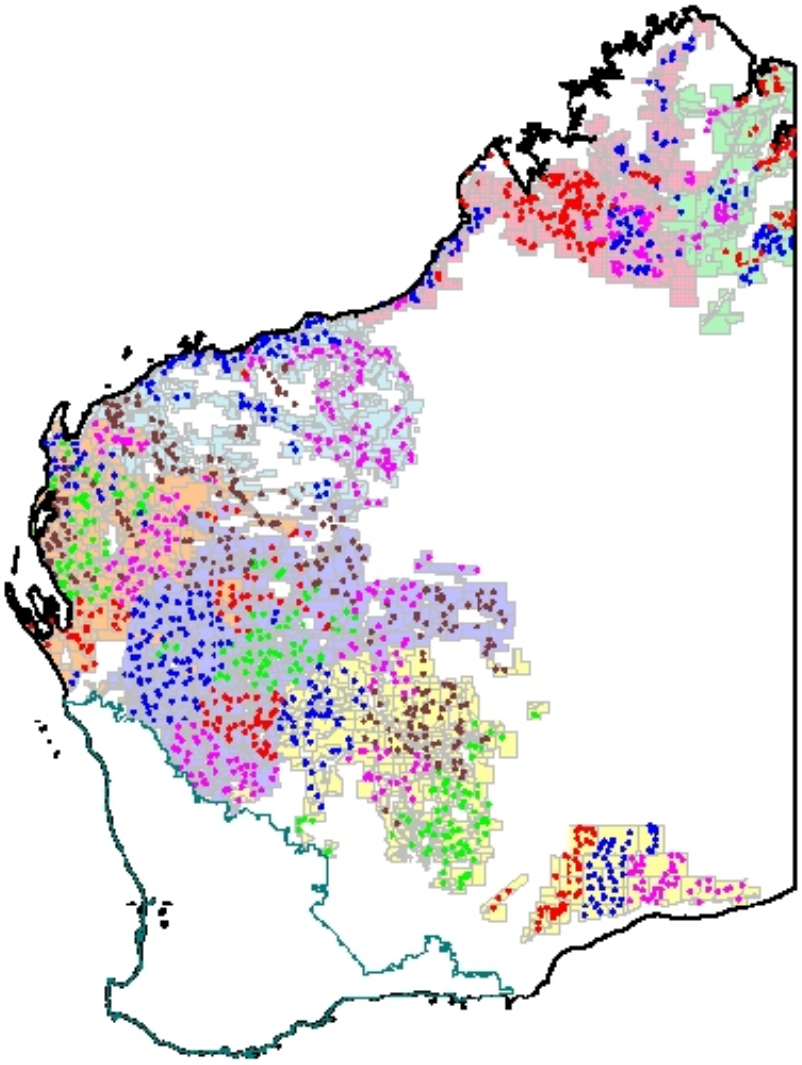


Figure 8: Location of WARMS Sites in the Rangelands

Separately to WARMS and the resource condition and inventory surveys, all pastoral leases in Western Australia are assessed on a one to six year cycle as part of the pastoral lease inspection process for the Pastoral Lands Board. The traverse and assessment techniques are based on those of the resource condition and inventory surveys, therefore providing the ability to compare condition now (and in the future) with condition at the time of original survey and subsequent lease inspections.

Inspection cycles are now determined by a method of categorising pastoral leases, classified by resource condition and infrastructure condition. The approach has the advantage of focusing on leases with environmental and/ or infrastructure issues. There are four categories from “Low Concern” (assessed on a six year cycle) to “High Concern” (assessed on a one year cycle).

Landscape Modification Assets

Landscape modification assets are numerous and ubiquitous, comprising every part of the Region. For the most part, the assets can be managed and used sustainably without adverse effects, however there are two threats which warrant special consideration. Open-cut mining of certain landforms, such as laterite ridges or magnetite outcrops, can result in the destruction of these landforms and consequently permanent alteration to the landscape. Similarly mining activities can result in the creation of permanent landscape features such as waterbodies and waste rock dumps. Numerous examples of waste rock dumps are visible around Kalgoorlie, and have become part of the recent historical and cultural landscape of the Goldfields.

Careful consideration should be given to activities which result in the destruction or creation of landscape features. Assessment of the environmental impact of such mining operations must include a consideration of the value of the landscape asset. The other threat to landscape assets is the much more subtle process of sediment transport. Overland, hydraulic (water-driven) or aeolian (wind-driven) transport of sediments is one of the natural processes that results in landscape diversity. Such natural processes occur over long periods of time and result in comparatively stable landforms. Accelerated sediment transport as a result of human activity represents a threat to these landforms in the form of erosion and deposition. Accelerated erosion of landforms can result in the degradation or destruction of the landform, and of the landform which receives the transported sediment. Thus erosion from a hillside with runoff into a stream not only degrades the slope of the hillside, but also degrades the stream. Landscape modification has particular impact on Indigenous landusers, where land forms are an integral part of cultural heritage through song cycles.

Weed and Feral Animal Management

Controlling the spread and abundance of feral animals and weeds on pastoral land is coordinated by Zone Control Authorities (ZCAs). They are considered to be key organisations for NRM action with considerable scope for integration of their activities with regional NRM planning and delivery. They are ideally placed to provide strategic direction on targeted investment in managing pest plants and and animals and the Rangelands NRM Co-ordinating Group will work with the Authorities to support strategic investment in monitoring and control measures throughout the Region.

Feral animals in the region include donkeys, cats, camels, goats, rabbits, horses, foxes, pigs and wild dogs. A range of control programs are in place to control the impact and spread of feral animals throughout the region. For example, the Donkey Management Program uses radio collars to track donkeys throughout the Kimberley. The tracking program has been expanding from south to north, with the final region, the North Kimberley, now being targeted. This has been a successful project and remains a priority.

There are two main groups in the Kimberley working on the management of weeds through best management practice, education and awareness – the National Prickle Bush Management Group and the East Kimberley Weed Working Group. The National Prickle Bush Management Group has developed best management practice manuals, with NHT funding, to enable land managers to develop strategic control methods in relation to density of weed infestations.

The ZCAs in the Gascoyne-Murchison are also working to coordinate control of pests and weeds. There has been increasing coordination of these activities with land assets contained within conservation estates. The main focus of the ZCAs in the sub-region are wild dogs and, to a lesser degree, cats and foxes, and in recent years, they ave been focusing on the potential impact of weeds. The Carnarvon ZCA recently secured funds to conduct a mapping and eradication project of Mesquite and Parkinsonia. A number of individual stations have also begun the process of weed control throughout the sub-region.

In the Goldfields-Nullarbor, the NHT funded Western Australian Goldfields Weed Strategy is seeing the development of a strategy, action plan and interactive website. The four LCDCs in the sub-region are

also supporting the creation of a weed identification booklet that is water proof, pocket size and sufficiently robust for people to have in their vehicles. Surveillance and alerting of weeds on the move is currently being addressed by the north Goldfields LCDCs, with the spread of weeds along transport routes. This highlights a future problem for the sub-region with new roads opening (Great Central Highway) and old roads being revitalised for 4WD tourism (eg Connie Sue Highway), which miss quarantine check points.

Wild dogs are also reported to be a constant problem in the Goldfields-Nullarbor as their numbers increase. Other animals of concern are rabbits, cats, goats, camels, donkeys and horses, as are increasing numbers of kangaroos.

Fire Management

Fire is a significant issue throughout the Rangelands, and a substantial project being undertaken to address it is the Kimberley Regional Fire Management Project (KRFMP). It is overseen by an incorporated body, which is responsible for:

- an extensive community education campaign on the responsible use of fire;
- the production of a field guide on grassland curing rates to assist land managers (and the operators of the Aerial Control Burning program) to determine suitable conditions for controlled burns;
- the FireFax service to pastoral managers which provides information to property owners and managers on the location and progress of fires on their properties;
- training for the owners and managers of pastoral businesses in the use of computer technology and internet-based tools for fire and land management;
- research on the impact of fire on the region's vegetation and wildlife.

In January of 2003 the KRFMP began a pilot project with two Aboriginal groups to train people in both contemporary and traditional fire management, creating Fire Control Teams (FCTs). Other work of the project continues to concentrate on fire and biodiversity through field based observations in strategic locations; remotely sensed, fire information, web-based tools development; and training for land managers. The Project intends to undertake further ction in a number of areas:

- sustainable pastoral management, training and employment;
- biodiversity assessment and management;
- fire information for Kimberley rangeland managers; and
- communication and assessment activities.

Indigenous Land Management

A number of specific, contemporary land uses are closely associated with the occupation and use of land by Traditional Owners, including community living areas and economic development opportunities. Most rangeland Aboriginal communities live on pastoral leases and on reserve lands. Living in homeland communities in most cases enables Aboriginal people to meet other specific community needs including:

- supplementing family incomes and improving community nutrition by hunting, gathering and fishing;
- performing cultural and religious practices specific to the group and to the location; and
- educating children in the social and cultural values of the group and management of the resources of the land for all of these purposes.

The Indigenous Land Corporation (ILC) assists Indigenous people to acquire and manage land in a sustainable way to provide social, cultural, environmental and economic benefits for themselves and future generations. Many contemporary Aboriginal landholdings were acquired as pastoral leasehold, not only to recognise Aboriginal peoples' traditional ownership or long term association with individual properties, but also to provide a community economic base (including for subsistence pastoralism). However, few of the lands held as pastoral lease are known to support profitable pastoral businesses.

Surveys conducted by other Australian Government and State agencies suggest that some properties are not only economically stagnant but are not actively managed for maintenance of either biodiversity or production values.

The situation confronting the properties is complex. The properties differ widely in their natural attributes, the state of the business assets at the time of acquisition, the purposes for which the properties were initially acquired and the landholders' current aspirations for the land. Consequently, the "problems" that the properties face have widely differing causes and potential remedies, and need to be investigated and addressed on an individual basis.

Within the Rangelands there are an increasing number of communities experimenting with small scale horticultural developments to meet community nutrition needs and to provide an independent income stream. This move will gain impetus from regional developments in the Rangelands to increase the areas developed for extensive horticulture (eg Ord Stage Two). Within such developments are opportunities for the intensification of bush foods and medicines production based on traditional knowledge and the use of Indigenous plants and animal species.

Incidental but economically significant opportunities arise from the exploitation of mineral resources on traditional lands, which is widespread in the Rangelands. Importantly, the native title process and corporate citizenry obligations provide a mechanism for exploitation of mineral resources that generate opportunities for independent income streams, employment, training and small business development.

A more detailed outline of Indigenous issues related to NRM is provided at Appendix VII.

Management of Unallocated Crown Land and Unmanaged Reserves

The administration and deposition of Crown land is the responsibility of the Department for Planning and Infrastructure and enacted through the *Land Administration Act 1997*, whilst section 33(2) of the *Conservation and Land Management Act 1984* enables management responsibility to be placed with CALM. The Department for Planning and Infrastructure's Land Asset Management Services team is responsible for discharging Crown land administration, management, development and deposition functions and ensures that Crown land is administered in accordance with the *Land Administration Act*. This includes detection of illegal occupation of Crown land, dealing with offences or hazards and arrangement of remediation with parties with regards to unauthorised structures etc.

Other management on Crown lands including the control of feral animals, weeds and fire pre-suppression, is covered in the following section on terrestrial biodiversity.

2.6.6 Land RCTs and MATs

RCT3: Maintain or improve soil surface condition throughout the Rangelands by 2025 with less then 10 percent of sites in poor condition, as measured by an integrated index of existing soil attribute measures, to be developed by 2008

- Pastoral lands show a stable or improving soil condition by 2020, with less than 10 percent of sites in poor condition as measured by WARMS, and other activities such as rangeland survey and pastoral lease inspection

RCT4: Eradicate or reduce the abundance and distribution of significant invasive and pest species by 2025 and limit new occurrences or introductions

RCT5: Maintain or improve frequency, density and cover of perennial vegetation for the purpose of protecting soil resources with less then 10% site in declining condition by 2025 as measured by an integrated index of existing measures, to be developed by 2008

- Pastoral lands show stable or improving protection of soil as assessed by perennial vegetation by 2020, with less than 10 percent of sites in declining condition as measured by WARMS, and other activities such as rangeland survey and pastoral lease inspection

Management Action Targets		Geographic Focus	Actions	Potential Partner Groups	Links to RCTs	Priority
Benchmark and Monitoring						
10 	**L1.** By 2008, the regions productive values and associated threatening processes have been identified, characterised and prioritised for the Rangelands	Regional	• Undertake Assessment of values and threats, • Include possible value-adding to threat assessment • Characterise and Prioritise • Identify and prioritise areas of significant erosion for intervention by 2008 • Collect baseline data on the condition of productive lands • Continue Rangelands surveys and develop reassessment schedule • Review the adequacy of existing ecological research to meet land managers needs and address gaps • Collect data on current stocking rates, land degradation, topsoil condition/compaction/erosion, weed invasion, water capabilities and access, salinity, pest species (native and non-native) • Identify biodiversity values including native vegetation, significant ecological communities and flora and fauna values on production lands	State Government Industry Research Institutions	RCT3 RCT4 RCT5	1B

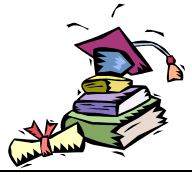
Management Action Targets		Geographic Focus	Actions	Potential Partner Groups	Links to RCTs	Priority
2 	**L2.** By 2006, establish benchmarks for the frequency, density and cover of perennial vegetation based on existing information and datasets	Regional	• Identify and address gaps in benchmarking in the Rangelands region • Identify existing datasets (WARMS and Pastoral Lease Inspection program, rangeland survey and inventory, and CALM data sources) and determine their application for establishing benchmarks; continue rangelands survey • Review the effectiveness of new/ current remote sensing technology for assessing rangeland condition by 2007 • Identification of appropriate remote sensing technology for assessing rangeland condition • fire scar/hot spot GIS mapping. Support to land managers to allow uptake of this technology	State Government Industry Research Institutions	RCT5 RCT6	1B
1 	**L3.** By 2008 develop an integrated index of existing soil and vegetation attribute measures for sustainable land use	Regional	• Identify all relevant soil and vegetation indices • Develop a soil and vegetation index to assist in developing best practice guidelines	Research Institutions State Government Industry	RCT3 RCT5	1A

On-ground Actions						
10 	**L4.** By 2010 70% of land managers are implementing ecologically sustainable management practises to balance economic, socio-cultural and environmental values of the land as measured through existing measures such as pastoral inspections	Regional	• Implement programs focused on matching stocking rate to land capability • Implement total grazing management systems • Monitor changes in grazing pressure with established indicators • Protect critical areas of the landscape still in good condition from degradation • Develop and protect long-term reference areas within management units • Develop Best Management Practice Modules, using sustainability indicators for pastoral and horticulture land, BMP Modules include: Fire Management, Nutrient Management, Sediment Control, Ground Cover, Chemical Management by 2008 • Best Practice guidelines researched and developed • Employ extension staff to support implementation and greater awareness • 70% of land managers have developed Property Management Plans, which include Best Management Practice Guidelines, and include strategies for management of: - fire, invasive species, soil, matching stocking rate to Food on Offer, water use, high biodiversity conservation values, hydrology and landscape function by 2010 • Adoption of Property Management Plans • Monitoring of planned objectives • Fire management and monitoring of area burnt • Extend programs to other land managers such as mining, tourism and conservation sector • 50% of land users/managers making improved management decisions to benefit native vegetation resulting from the use of a suite of management decision tools, including remote sensing by 2010 • Investigations into the availability and practicability of latest technology for measuring native vegetation change • Promotion of tools for mapping landscape changes • Training in package associated with tool suite • Survey of the uptake of land users of tool suite.	State Government Local Government Industry groups Research	RCT1 RCT3 RCT5	1A

2 	**L5.** Develop and commence implementation of 2 additional landscape scale recovery plans in priority areas by 2010	Regional Priority Areas	• Identify priority areas in consultation with all stakeholders by 2006 (e.g. top of catchments) for program implementation of landscape recovery • Investigate & develop landscape recovery models applicable to the Rangelands • Investigate and promote the use of local, native species for landscape rehabilitation and pasture improvement • Identify and promote case studies of successful landscape recovery • Implement design actions in identified priority areas including Roderick River • Formation of catchment groups to address detrimental processes in priority areas based on sound ecological modelling and understanding • Development of catchment management plans for priority catchments by 2010 • Protect critical areas of the landscape still in good condition from degradation • Increase water retention (water efficiency) reducing runoff and erosion in catchment areas through integrated land management approaches • Minimise degradation caused by infrastructure such as roads, causeways and culverts etc • Investigate and promote incentive mechanisms that encourage land managers to address historical degradation	Research institutions State Government Industry groups	RCT3 RCT5	1B
1 	**L6.** Implement best practise management soil conservation on 20% of properties by 2010	Regional	• Determine best practice approaches to soil management by 2006 • Develop best practise management soil conservation in horticultural precincts by 2010 • Monitor the uptake of best practices • Monitor and evaluate the changes in soil condition/conservation in horticultural precincts • Develop training programs for landholders to increase ability to improve or maintain soil condition (chemical, physical and biological processes) supported by an extension officer • Gascoyne-Murchison is a priority region for soil conservation initiatives	Research institutions Community groups Local Government Industry groups	RCT3	1A

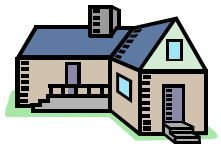
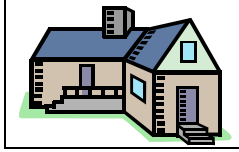
10 	**L7.** Control of at least 25% of priority significant invasive or pest species by 2010	Regional	• Prioritise significant invasive species and infestations for control management by 2007 • Undertake risk assessment of invasive and feral animal and weed species by 2005 • Research impacts of exotic and native weed species • Develop best practices • Undertake weed mapping • Develop and implement a staged works program for control and eradication based on sound scientific knowledge • Significant ecologically invasive and pest species management plans are developed and implemented by a minimum of 50% of land managers by 2010 • Management Plans Implemented • Resources are allocated for implementation into the future • Review eradication programs in 2008 • Review control programs in 2008 • Control of native and exotic woody weeds • Involve all land users in management and control of weeds	State Government Federal Government Industry groups Research institutions Community groups Industry	RCT1 RCT9 RCT4 L41	1A
2 	**L8.** Within five years kangaroo numbers are at sustainable levels and do not contribute to ecologically unsustainable grazing	Regional	• Review kangaroo management plans and quota system • Conduct major review of Kangaroo Management Plans in 2007 • Research and model ecologically sustainable kangaroo numbers to support management plans • Implement programs for controlling kangaroo numbers • Seek views from Indigenous Organisations	State Industry Land Managers Local Government Traditional Owners	RCT3 RCT5	1C
10 	**L9.** 80% of land managers are implementing approved fire management plans in priority areas, that address values including sustainable production and biodiversity conservation by 2009	Kimberley Pilbara	• Fire management included in property plans • Involve Indigenous organisations in formation of burn programs • Training available for pastoral property planned burn programs • Aerial control burn work, integrated with on-ground follow up burns • Identify Priority areas • Access to Aerial Control Burn programs subsidised	State Industry Land Managers Local Government Traditional Owners	RCT1 RCT3 RCT5 RCT6	1B

Institutional Frameworks, Planning and Policy						
10 	**L10.** Identify five alternative sustainable land use activities to support economic diversification by 2010	Regional Site Specific	• Research sustainability of alternative land uses • Establish principles and benchmarks for sustainable development • Review efficiency of current system of applying for diversification permits • Identify alternative economic use of vegetation to maintain stewardship of land and provide management advice	Industry State	RCT3	1C
12 	**L11.** By 2010 20% developments are consistent with the principles of ecologically sustainable development	Regional	• Establish sustainable development plans that incorporate the protection and maintenance of ecosystem integrity and function • Actively promote the recognition and adoption of best practice in infrastructure • Review procedures for developing, disseminating and promoting “best practice” guidelines including through approvals processes, regulations and codes of practice • Where appropriate encourage rehabilitation of biodiversity • Existing developments are encouraged to undertake ecologically sustainable development planning • All new developments are encouraged to develop waste minimisation, energy efficiency, resource sharing and water efficiency programs • Assessment of new developments consider cumulative impacts of developments on natural resources in the area • Develop partnerships with stakeholders to establish a cooperative framework for managing tourism development (eg, camping, walk-trails, access) • Incorporate Natural Resource management in Regional and local planning strategies and Town Planning Schemes and ensure consistency with sustainability principles and NRM plans in the region • Support recycling opportunities, waste management • Ensure culturally sensitive areas are preserved	State Govt Local Govt Community Industry	All	1B
12 	**L12.** Complete review of Rangelands NRM planning to ensure alignment of community and government priorities by 2010	Site specific	• Identify current policy constraints on land managers • Work with state agencies and other relevant bodies to develop incentives for NRM investments on lands with insecure tenure • Investigate and promote mechanisms to encourage land managers to address historical degradation eg rate adjustments • Encourage appropriate and consistent use of existing legislation and regulation for the protection of rangeland condition • Engage mining in the review and future iterations of NRM planning	State Government Land managers Peak Bodies	All	1B

12 	**L13.** Develop tourism management plans for 8 high priority areas, by 2010	2 priority areas in each sub-region	• Management Plan developed for priority tourism areas, including cultural tourism sites • Education program for visitors to raise awareness of potential impacts • Develop code of conduct for visitors to pastoral leases • Develop planning framework for nature based tourism with stake holder involvement	State Local Government Industry Traditional Owners	RCT3 RCT5	1A
Education, Awareness and Further Engagement						
11 	**L14.** By 2008 develop training, accreditation and incentives packages to support the uptake of sustainable land management and enhance access to information		• Consult with land managers to determine training and educational needs and to identify useful incentives • Develop useful incentives packages and gain agency, government and industry support for the development of these packages • Develop a number of educational options such as establishing interpretive trails in 'iconic tourist destinations' to allow hands on learning, experiences and sustainable land management practices • Increase awareness and access of information held by government and non-government entities • Tool box developed to encourage sympathetic land uses for biodiversity outcomes • Identify methods of ecological sustainable grazing management to achieve accreditation of property • Identify delivery mechanisms and employ appropriate implementation team • Encourage land managers at enterprise, sub-regional and regional scale to participate in programs to increase understanding of natural systems and the identification of critical areas and potential threats to them. eg EMU	State agency NGOs Community Groups Schools Local Government Industry Peak Bodies Traditional Owners	RCT1 RCT3 RCT4 RCT5	1B
11 	**L15.** By 2010, there is an increased understanding of climate variations and the subsequent impacts on natural resources	Regional	• Develop models to assist in predicting changes in climate • The consequences of climatic variables are incorporated into resource management planning processes (to be ascertained from predictive models and indices) • Develop models to predict the effects of changed climate on natural resource values	Research institutions Industry Community State Government	RCT1	1A

2 	**L16.** Public Awareness programs developed for the movement and control of significant invasive and pest species including ecologically significant species by 2008	Regional	• Continue to educate the community on weed identification and removal programs and feral animal management • Improved understanding of the management options for WONS and other high priority weed • Better coordination of communication • Conduct media campaign • Produce Plain English brochures for communities • Establish appropriate quarantine and hygiene procedures and facilities • Promote awareness and implantation of existing weed strategies eg Goldfields Weed Strategy and State Weed Plan • Encourage and support land managers to report and manage new occurrences • Develop and promote information packages and codes of practice for specific community sectors • Education programs on the benefits of local native species in gardens and parks • Education programs on Cane Toad identification implemented throughout the Kimberley including brochures, signs and forums • Best Management Practice Guidelines promoted for weed control by 2008 • Education package developed including: workshops, brochures, field days, bio-control, ranger programs • Encourage inclusion of weed control strategies in development approvals and contracts for works	State Local Government Peak Bodies Industry	RCT1 RCT4 RCT6 RCT7 RCT9 RCT14 RCT15	1B

11 	**L17.** By 2006 an agreed engagement plan developed and implemented in order to conduct a more complete engagement of stakeholders and continued involvement of stakeholders in the NRM planning and implementation process *This MAT and actions are relevant across all scapes	Regional	• Prepare the plan • Implement the plan • Engage with Indigenous people, mining industry, fishing and aquaculture industry, pastoral industry, local government, conservation groups and recreational and special interest groups (e.g. caving and 4WD groups) • Priority stakeholders to target for engagement are indigenous people and the mining industry • Develop community industry partnerships and funding arrangements • Identify projects for industry to make contributions • Address landscape pressures resulting from mining activities • Implement projects in partnership with industry • Develop mechanisms for using interest from bonds for NRM in region of mine • Develop mechanisms for using interest from environmental bonds payed by mining companies or conservation offsets (Environmental Offsets EPA Preliminary Position Statement No. 9, 2004) for NRM in the region of mine • Investigate the potential role of NRM groups in brokering or facilitating such agreements.	All	RCT1 RCT2	1A
Cultural Heritage						
11 	**L18.** Develop Indigenous traineeships and ranger programs in consultation with Traditional Owners by 2006 *This MAT and actions are relevant across all scapes	Regional	• Develop traineeship programs in consultation with Traditional Owners • Implement Ranger Programs, including Sea Rangers in coastal areas • Encourage work opportunities	State Indigenous Local Government Traditional Owners	All	1A

13b 	**L19.** By 2010 identify areas of significant heritage and cultural value and maintain the integrity through ensuring resource use does not compromise these values *This MAT and actions are relevant across all scapes	Site specific Priority areas	• Survey the community and stakeholders to determine areas of significant heritage value • Ensure that current and future management plans and processes incorporate and address these values • Aboriginal people are involved in making decisions about land development • Local historical and Cultural knowledge mapped and documented so as to include traditional ecological management across the Rangelands by 2006 • Marrying of traditional knowledge and science for monitoring rangeland condition • Traditional and scientific knowledge incorporated in monitoring Rangelands condition • Demonstration days and field trips undertaken • Encourage projects to protect and restore sites of significant cultural value and protect confidentiality of sites • Develop policies, protocols and strategies to respect the protection of culturally sensitive knowledge • Examine the potential for IPAs to protect culturally significant sites	State Govt Community Industry groups Local Govt Traditional Owners	RCT2	2A
13a 	**L20.** Twelve property management plans developed for Aboriginal managed lands by 2010	Regional	• Production of property management plans that include strategies for management of:; fire, invasive pests, soil, matching stocking rate to Food on Offer, water use, high conservation values, hydrology and landscape, , water use, high conservation values, hydrology and landscape, function"	State Government Industry Traditional Owners Community groups Local Government	RCT2 RCT3 RCT4 RCT5	2B
13b 	**L21.** Restoration and protection programs are in place for significant European heritage sites by 2010 *This MAT and actions are relevant across all scapes	Regional	• Identify significant European heritage sites in collaboration with all stakeholders by 2007 • Develop and implement appropriate management plans for these sites • Develop and preserve the oral history of the region	State Government Local Government	RCT1 RCT2	2B

2.6.7 Terrestrial Biodiversity

Terrestrial biodiversity refers to the range of biological organisms that occur naturally in Western Australia's Rangelands and are land based, as distinct from freshwater/ natural saline aquatic organisms and marine organisms. However, terrestrial, aquatic and marine biological systems are not independent and have a close interconnectivity and influence on each other. This category has been used to highlight strong links between terrestrial biodiversity and land uses, but linkages to the other categories of biodiversity will be pointed out throughout each category description.

Terrestrial biodiversity assets are divided into "Living Assemblages" and "Species and Populations" (Figure 3).

Living Assemblages

Living assemblages have been described in the broad categories of native vegetation, threatened ecological communities, refugia and areas of high endemism and species richness. These will be discussed in greater detail below. To provide a context at a landscape level, it is useful to firstly consider the IBRA 5.1 bioregions that occur within the Rangelands NRM Region.

Interim Biogeographical Regionalisation of Australia

At a national level, the Department of Environment and Heritage, in collaboration with the States/ Territories, developed an interim framework for conservation planning and sustainable resource management within a bioregional context. IBRA 5.1 classifies the continent into broad landscape patterns based upon the interrelationships between factors such as geology, climate, and native vegetation. IBRA 5.1 broadly incorporates terrestrial and aquatic elements of biodiversity, but it does not specifically classify wetlands or waterways. The Directory of Important Wetlands of Australia provides a basis for classifying inland water systems of national significance.

There are 21 IBRA 5.1 regions that have the majority of their extent within the Rangelands' boundary (Figure). These IBRA 5.1 regions are further divided into sub-regions, 39 of which have the majority of their extent in the Rangelands (Table 5).

CALM recently released *A Biodiversity Audit of Western Australia's 53 Biogeographical Sub-regions* in 2002, which provides summary descriptions of geographical and biological elements of each of the IBRA 5.1 sub-regions. The Audit also provides statements of biodiversity condition and recommendations for conservation planning. Currently there is no formal mechanism for bioregional planning in the State, but the Audit is considered to be the first step in achieving this type of biodiversity planning. The State Government's proposed Biodiversity Conservation Strategy, and associated Biodiversity Conservation Act, will provide a formal mechanism for bioregional planning in the future.

The Audit provides a general overview of available information on biodiversity for the sub-regions. However, in light of recognised gaps in knowledge, the Audit should not be considered to represent the complete picture. Efforts to update and maintain the Audit will be on-going with a review expected in approximately 18 months of the publication of the current Audit. Information for the IBRA 5.1 sub-regions contained within the Rangelands can be found in the *Western Australian Biodiversity Audit* (CALM, 2003).

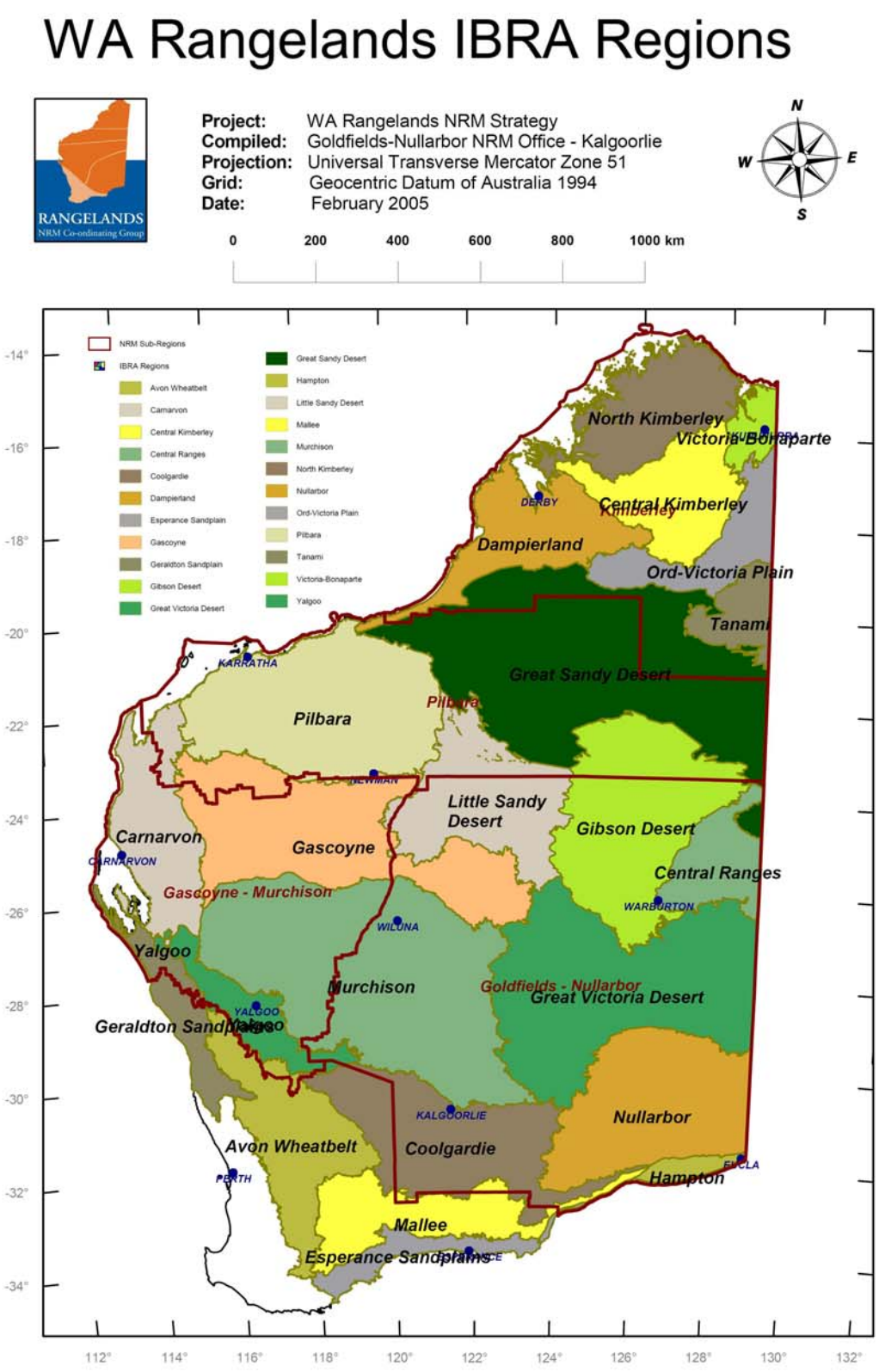


Figure 9: IBRA 5.1 Regions of the Rangelands

Table shows IBRA 5.1 sub-regions that occur in the Rangelands and provides information on the overall condition derived through the National Land and Water Resources Audit (NLWRA) and the State Comprehensive, Adequate and Representative (CAR) reserve analysis.

Table 5: Overview of IBRA 5.1 Sub-regions Occurring In The Rangelands NRM Region.

Includes NRM sub-region in which it occurs, continental landscape stress class (DEH, 2001) (1 = most stressed, 6 = least stressed), percentage of sub-region in conservation reserve (IUCN and Section 33(2)), number of Beard's vegetation associations occurring in sub-region and percentage of vegetation association with greater than 15 percent of their current extent in conservation reserves (IUCN and Section 33(2)).

IBRA 5.1 Sub-region	NRM Sub-region Kimb – Kimberley Pilb – Pilbara GM – Gascoyne-Murchison GN – Goldfields-Nullarbor	Continental Landscape Stress Class [2](NLWRA)	% of sub-region in IUCN I-IV and CALM Act s. 33(2)	No of veg types	% of veg types with greater than 15% in IUCN I-IV and CALM Act s. 33(2)
Carnarvon 1	GM, Pilb	3	14	38	21
Carnarvon 2	GM	3	9	82	15
Central Kimberley 1	Kimb	5	6	43	12
Central Kimberley 2	Kimb	5	0	40	0
Central Kimberley 3	Kimb	6	8	23	9
Central Ranges 1	GN	6	0	20	0
Coolgardie 1	GN	5	13	22	5
Coolgardie 2	GN	4	14	67	39
Coolgardie 3	GN	5	4	62	5
Dampierland 1	Kimb	4	2	65	5
Dampierland 2	Kimb, Pilb	6	<1	44	0
Gascoyne 1	GM, Pilb	3	3	34	3
Gascoyne 2	GN, GM	5	10	26	15
Gascoyne 3	GM	4	10	50	18
Geraldton Sandplain 1	GM	3	24	32	22
Gibson Desert 1	GN, Pilb	6	15	22	27
Gibson Desert 2	GN, Pilb	6	0	14	0
Great Sandy Desert 1	Pilb, Kimb	5	<1	39	3
Great Sandy Desert 2	Pilb, Kimb	5	4	33	9
Great Victoria Desert 1	GN	6	7	27	22
Great Victoria Desert 2	GN	5	9	31	23
Great Victoria Desert 3	GN	6	10	11	27
Hampton	GN	6	11	8	50
Little Sandy Desert 1	Pilb	6	37	8	37. 5
Little Sandy Desert 2	GN, Pilb, GM	6	1	30	7
Murchison 1	GN, GM	3	7	91	26
Murchison 2	GM	3	4	58	19
North Kimberley 1	Kimb	6	14	27	19
North Kimberley 2	Kimb	6	17	13	31
Nullarbor 1	GN	6	36	20	55
Nullarbor 2	GN	6	5	18	6

[2] NLWRA 'Continental Landscape Stress Class' from a range of condition and trend attributes. Information can be found in (DEH, 2001)

Ord Victoria Plains 1	Kimb	6	15	38	27
Ord Victoria Plains 2	Kimb	4	<1	60	0
Pilbara 1	Pilb	4	4	48	4
Pilbara 2	Pilb	4	1	29	0
Pilbara 3	Pilb	6	14	49	22
Pilbara 4	Pilb	3	7	40	15
Victoria Bonaparte 1	Kimb	4	6	38	8
Yalgoo	GM, GN	4	17	79	16

Source: CALM CAR Reserve Analysis July, 2003.

Native Vegetation

Native vegetation is described at levels from sub-association to major vegetation groups. For the purpose of the Rangelands NRM Strategy, vegetation will be described at a broad level using major vegetation groups (NLWRA, 2001) and in greater detail using Beard's Vegetation Association Mapping.

At the broad level the *Australian Native Vegetation Assessment 2001* (NLWRA, 2001) has mapped and described native vegetation using major vegetation groups. This assessment shows the Southern Rangelands dominated by Acacia forest and woodlands, Acacia shrublands and Hummock grasslands (Spinifex). The Northern Rangelands are dominated by Hummock grasslands (Spinifex) in the Pilbara region with the Kimberley region dominated by Acacia shrublands and Tropical Eucalypt woodlands/ grasslands. Areas of Mangrove occur on the coast north of Carnarvon. These major vegetation groups correlate approximately with broad geological and climatic classification such as tectonic units and climatic zones respectively.

Beard described vegetation associations (assemblages of native plants that occur on particular soil types) at a structural level to a scale of 1:250,000, with additional information on associations and communities. The conservation status of vegetation associations has been described by Hopkins *et al*., (1996), based on modified Beard mapping.

In Western Australia, 819 vegetation associations have been described. Of these, 565 occur within the Rangelands, ranging in area from 24 hectares (*Eucalyptus microtheca* Coolibah Savannah Woodlands over Ribbon Grass) to approximately 26 million hectares (Hummock/ Spinifex grasslands with Bloodwood and scattered shrub). Of the 565 vegetation associations that occur throughout the Rangelands, 511 occur on lands held under pastoral lease, 293 on lands managed by CALM and 493 on other Crown reserves, UCL, UMRs and Aboriginal reserves. This translates to approximately 90.5 million hectares under pastoral lease, 19.4 million hectares under CALM management and 113.7 million hectares under other Crown reserves, UCL and UMRs (Table 6).

Restricted vegetation associations are considered important to biodiversity conservation because they only exist within a limited area. In the southwest land division, vegetation associations with a pre-European extent of less than 2,000 hectares are considered to be of significance for biodiversity. Vegetation association in the Rangelands are generally much larger than those located in the southwest land division, therefore for the purpose of the strategy, vegetation associations with a pre-European extent of less than 10,000 hectares are being considered as having potential importance for biodiversity conservation. It must be noted that areal extent of native vegetation is not the definitive characteristic of potential importance to biodiversity and that important processes and functions, of which there is limited knowledge, occur at a variety of spatial scales within vegetation associations.

Table 6: Number of Vegetation Associations that Occur in the Western Australian Rangelands NRM Region.

Note: with relation to CAR reserve system requirements and the number of restricted vegetation associations in the classes of 10,000 hectare and 2,000 hectare.

Category	Number of vegetation associations
Vegetation Associations in Rangelands NRM Region	565
Vegetation Associations not represented in Section 33(2) + IUCN 1 - 4	278
Vegetation Associations 1 - 15 percent in Section 33(2) + IUCN 1 - 4	172
Vegetation Associations more than 15 percent Section 33(2) + IUCN 1 - 4	115
Vegetation Associations between 10,000 and 2,000 hectares	65
Vegetation Associations 2,000 hectares or less	24

The condition of native vegetation throughout the Rangelands, in a biodiversity context, is largely unknown due to the extent of the Region, limited resources to adequately measure ecological condition and the complex nature of effectively measuring biodiversity in the Rangelands. Monitoring of particular attributes of vegetation condition in isolation can lead to misleading conclusions.

For example, WARMS monitoring has provided a measure of range condition over the pastoral rangelands and includes vegetation measures as an attribute and indicates a positive change in range condition. At the same time processes such as EMU mapping show patterns of landscape incision, erosional processes and desiccation from whole catchments to individual landscape features (Pringle *et al*., unpublished, submitted). This paper shows that the results of both methodologies are correct, but they are reporting on different components of a hierarchical model of ecosystem patterns. Monitoring of native vegetation for biodiversity needs to regard these issues and consider changes in patterns of intact and degrading landscapes. It is important to note that native vegetation is often used as a surrogate for biodiversity, but there is growing literature that suggests that other aspects of biodiversity need to be measured directly.

National and State policies aim to establish a CAR reserve system (see page 69 for details on CAR) to provide for the long-term conservation of diversity of ecological systems and species in secure tenure. A nominal target figure for representation of vegetation association in such a reserve system has been set at a minimum of 15 percent of pre-European extent, though this may sometimes need to be higher (eg to meet criteria such as adequacy). Currently, more than half of described vegetation associations fall below this figure (Table 7) and in greater detail in Appendix V). Through processes such as purchase, acquisition and the 2015 pastoral lease exclusions, the representation of vegetation associations is improving. However, the establishment of a CAR reserve system may not be achieved in the short to medium term due to limited resources, competing land uses is a national priority and stakeholder interests. The establishment of a formal reserve system consistent with CAR criteria is an explicit State Government policy and a key objective in the Rangelands.

Off-reserve measures will be necessary in addition to the CAR reserve system, in order to help sustain the CAR reserves in perpetuity, but also to achieve biodiversity. However, even with a reserve system that meets CAR requirements, there will always be biodiversity assets in the approximately 85 percent of the landscape that the formal reserve system does not capture. In this context protection of the range of biodiversity values in the Rangelands will be dependant on implementation of effective protection by reserves. This is covered in more detail in ‘Use and Value’ of terrestrial biodiversity.

There is also scope to incorporate traditional and contemporary knowledge into formal descriptions of vegetation in the future.

Threatened Ecological Communities

An ecological community is defined as a naturally occurring biological assemblage in a particular type of habitat. Threatened ecological communities (TECs) are ecological communities that are considered to be critically endangered, endangered or vulnerable (see Appendix V - Classification Categories of Species and Communities at Threat). The procedures and criteria for determining whether a threatened ecological community falls into one of these categories have been developed by CALM, based on those developed by the IUCN for threatened species ad used internationally, and are applied by the Western Australian Threatened Species Unit (WATSCU). WATSCU also maintains a list of ecological communities that are considered a priority for further investigation.

Unlike threatened flora and fauna, which are defined and provided for in the *Wildlife Conservation Act, 1950* and given legal status in a notice in the Government Gazette, TECs are not yet protected by specific legislation. Currently, a formal but non-statutory process, based on advice from a scientific advisory committee coordinated by CALM to determine conservation status (*Wildlife Conservation Act, 1950*), allows for TECs to receive endorsement from the State Minister for the Environment as to their conservation category (as outlined in the previous paragraph). Legal recognition of TECs awaits the passage of the State Government's proposed Biodiversity Conservation Act

Table 7 lists the TECs found in the Rangelands NRM region. Note that some of these contain organisms that would be considered aquatic biodiversity.

Table 7 Threatened Ecological Communities Found in the Rangelands NRM Region.

Community identifier	Rangelands NRM sub-region Kimb – Kimberley Pilb – Pilbara GM – Gascoyne-Murchison GN – Goldfields-Nullarbor	Community name	Category of Threat and criteria met under WA criteria**
39. Camerons*	GM	Camerons Cave Troglobitic Community	CR B) i), CR B) ii)
41. Bundera*	GM	Cape Range Remipede Community	CR B) ii)
44. Roebuck Bay mudflats	Kimb	Species-rich faunal community of the intertidal mudflats of Roebuck Bay	VU B)
46. Themeda Grasslands	Pilb	*Themeda* grasslands on cracking clays (Hamersley Station, Pilbara). Grassland plains dominated by the perennial *Themeda* (kangaroo grass) and many annual herbs and grasses.	VU A)
67. Monsoon thickets	Kimb	Monsoon thickets on coastal sand dunes of Dampier Peninsula	VU C)
78. Ethel Gorge	Pilb	Ethel Gorge aquifer stygobiont community	EN B) ii)
80. Theda Soak	Kimb	Assemblages of Theda Soak rainforest swamp	VU A), VU B)
81. Walcott Inlet	Kimb	Assemblages of Walcott Inlet rainforest swamps	VU B)
82. Roe River	Kimb	Assemblages of Roe River rainforest swamp	VU B)
84. Dragon Tree Soak	Kimb	Assemblages of Dragon Tree Soak organic mound spring	EN B) i)
85. Bunda Bunda	Kimb	Assemblages of Bunda Bunda organic mound spring	VU A), VU B)
86. Big Springs	Kimb	Assemblages of Big Springs organic mound springs	VU A), VU B)

89. North Kimberley mounds	Kimb	Organic mound spring sedgeland community of the North Kimberley Bioregion	VU A), VU B)
92. Black Spring	Kimb	Black Spring organic mound spring community	EN B) i), EN B) ii)
95. Mandora Mounds	Kimb	Assemblages of the organic springs and mound springs of the Mandora Marsh area	EN B) iii)
99. Depot Springs	GN	Depot Springs stygofauna community	VU B)

* Interim recovery plans have been developed for these TECs.
** E – Extinct, CR – Critically Endangered, EN – Endangered, VU – Vulnerable
Criteria can be viewed at http://www. naturebase. net/plants_animals/watscu/pdf/tec/lists_criteria. pdf and more information is available in Appendix V

Refugia, Endemism and Species Richness

Much of the biodiversity that exists in the Rangelands is subject to pressures that can degrade the condition and integrity of species and even entire systems. Areas where these pressures are lessened due to particular factors are important refugia to these species and systems. Areas in which organisms have a higher level of "fitness for survival" also provide a stronghold, even under natural extremes or fluctuations in environmental conditions. For example, coastal islands are often excellent refugia as they are isolated from the mainland. In many cases exotic predators and/ or weeds have not had deleterious effects, or populations of nuisance species are small enough for eradication to be possible.

For example, in the Shark Bay World Heritage area, Bernier and Dorre Islands were first leased for pastoral purposes in 1864 but, reportedly, grazing only occurred over a 10 year period on Bernier and not at all on Dorre Island. Subsequent changes in tenure eventually led to these islands becoming nature reserves under the *Conservation and Land Management Act 1984*. Goats were completely eradicated on Bernier Island in 1984 (Morris, 1995). Five threatened mammal species occur on Bernier and Dorre Islands, four of which no longer exist on the mainland (CALM, 2000). These and other islands along the Rangelands' coast provide important refugia for mammalian fauna.

Other important refuge areas occur on the mainland, often in the form of rocky outcrops, ridges and other areas inaccessible to domestic and wild stock, wetlands, springs and soaks, and caves, along with intact natural areas. There has not been any formal data basing or definition of refuge areas, in Western Australia and hence little data can be presented on the state or condition of refuge areas other than in documents such as the *Shark Bay Terrestrial Reserves Management Plan*. The *Biodiversity of Western Australia's 53 Biogeographical Sub-region* (2002) does contain some information on refugia based on expert opinion from each of the IBRA 5.1 sub-regions eg Paruku Wetlands (Ord Victoria Plains 2), Millstream Wetlands (Pilbara 2), Wooleen Lake (Murchison 2) and cave systems found on the Nullarbor Plain (Nullarbor 1). These refuges are extremely important for many animals exhibiting short range endemism, such as the camaenid land snails of the Kimberley.

Further information can be found at http://www.deh.gov.au/biodiversity/publications/series/paper4/.

Endemism relates to species of flora and fauna and invertebrates that only occur within a local area or to species that are wide spread but only found in Western Australia. Of the known flora for the Northern and Eremaean phytogeographic provinces, 14.3 percent and 50.4 percent respectively are endemic to Western Australia (Beard *et al*., 2000). Areas known for high levels of endemism are not well mapped or recorded, though the Biodiversity Audit contains information based on expert knowledge at IBRA 5.1 sub-region level (eg a high number of endemic species have been recorded in the Mitchell sub-region (North Kimberley 1), ChichesterHamersley sub-region (Pilbara 13), Cape Range sub-region (Carnarvon 1) and the eastern Goldfields sub-region (Coolgardie 3). The karst communities of the Nullarbor (Hampton), Cape Range (Carnarvon 1) and the Kimberley also contain high numbers of endemic invertebrate species.

Geographical isolation often leads to high degrees of local endemism. The presence of isolated features in the landscapes, such as the ironstone ranges, greatly increases the likelihood of short-range endemic fauna. These areas support high numbers of endemic plant species and are likely to have an associated endemic invertebrate community (PER, p.82).

Species richness relates to the number of known species present within a given area. As published in 2000, the Northern Province contains 2,140 flora species and the Eremaean province contains 3,977 flora species (Beard *et al,* 2000). Unlike the southwest land division, where work has been undertaken to map areas of plant species diversity (taking into account sampling bias), species diversity has not as yet been mapped for the Rangelands. How and Cowan have recently submitted a paper that looks at vertebrate patterning throughout the State.

The National Biodiversity Hotspots Program was announced in October 2003 and aims to "*increase public awareness of the cost effectiveness of strategic and timely action to conserve biodiversity*" (DEH, 2004). Biodiversity hotspots exhibit attributes of high species richness and endemism. The Program has identified 15 national biodiversity hotspots, four of which occur in the Rangelands. These are the North Kimberley, Hamersley/ Pilbara, Carnarvon Basin and the Geraldton to Shark Bay Sand Plains.

Cave systems also provide refugia, show high levels of endemism and species richness. To date the most diverse subterranean ecosystems appear to be Cape Range, Barrow Island, the calcretes aquifers of the Yilgarn, and the Kimberley Devonian reef. Other areas such as the Nullarbor karst may have similar levels of endemism and species richness among invertebrates however, little sampling in these areas has been done.

Species and Populations

The following section outlines the Rangelands' flora and fauna, including threatened species, summarised below in Figure 10.

Threatened Flora

The *Wildlife Conservation Act 1950* provides for protection of flora considered threatened or rare. Species that are potentially at threat or rare are identified in surveys and their status submitted for review to the CALM Threatened Species Scientific Committee administered by CALM. Ministerial approval is required for a species to be added to the threatened flora species list or for the conservation status of a species to be changed.

The conservation classifications include flora that are critically endangered, endangered, and vulnerable, all of which are listed under the *Wildlife Conservation Act 1950* as well as "*rare or likely to become extinct*" (threatened). CALM also maintains a non-statutory list of priority taxa. Priority taxa are divided into four categories. Categories for Priority One, Two and Three taxa are segregated on the basis of the number of individuals and populations, and Priority Four taxa are rare but not at the perceived level of threat of species that have recently been taken off the threatened list.

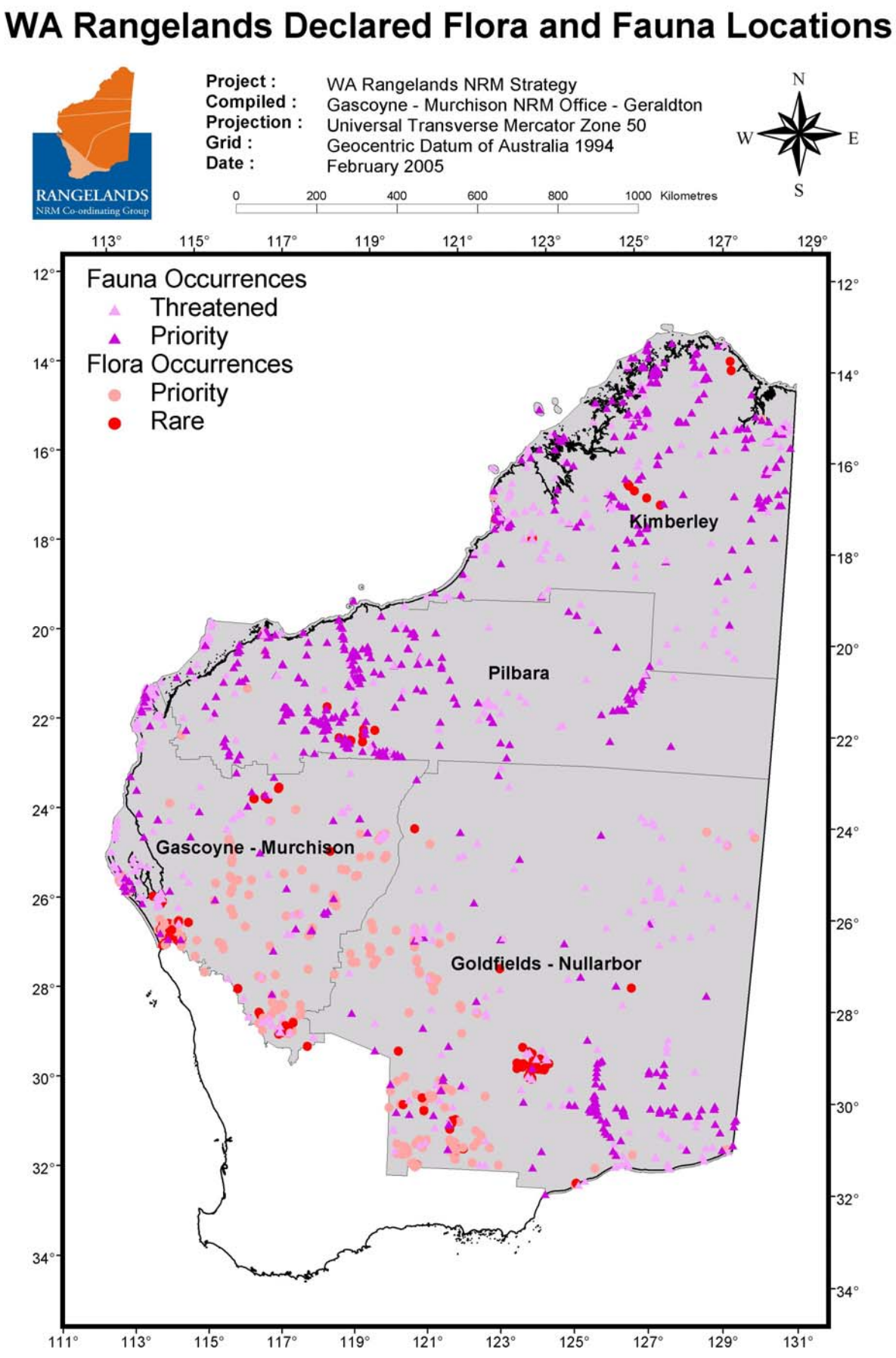


Figure 10: Declared Rare Flora and Fauna in the Rangelands

Table 8 shows the numbers of threatened and priority flora for each of the Rangelands' sub-regions and for the Rangelands as a whole.

Table 8: Number of Threatened and Priority Flora for Each of the Rangelands NRM Sub-regions and the Rangelands as a Whole.

Note that the totals for threatened and priority flora species are not equivalent to the sum of the sub-region as species may occur in more than one sub-region.

Conservation Code	Kimberley	Pilbara	Gascoyne-Murchison	Goldfields-Nullarbor	Whole-of-Rangelands
Critically Endangered (CR)	1	0	9	2	12
Endangered (EN)	1	0	7	2	10
Vulnerable (VU)	2	2	4	7	13
Priority 1 (P1)	42	34	95	83	168
Priority 2 (P2)	43	27	63	60	123
Priority 3 (P3)	41	40	79	77	145
Priority 4 (P4)	6	5	35	35	44
Total	**136**	**108**	**292**	**266**	**515**

There are other recovery plans under development in the Goldfields and three Interim Recovery Plans (IRPs) in existence. IRPs include *Myriophyllum lapidocola*, *Eremophila brevis* and *Davesia microcarpa*. Recovery Plans (RPs) are being developed (in conjunction with Portman Mining and the GFTFRG) for *Tetratheca paynterea*e and *Rinocarpos brevis*. Management of threatened flora is predominantly undertaken and coordinated by CALM through Regional and District Threatened Flora Management Programs. These programs review the status of declared threatened flora and priority taxa, develop local priorities and outline management needs. However, currently only the Mid West CALM Region (covering the Gascoyne-Murchison), has a program in place and one is being prepared for the Goldfields Region. It is highly likely that there exists many flora species that meet the criteria for threatened or priority taxa but they have not been listed in the absence of these programs in conjunction with regional and district threatened flora programs, CALM prepares recovery plans (RPs) and IRPs. These plans are implemented by recovery teams that include stakeholders. CALM aims to develop RPs and IRPs for all species (taxa and ecological communities) that are ranked as critically endangered and inthe highest priority species. Categories of threat, beginning with those that are Critically Endangered. Currently in the Rangelands there are only five recovery plans and these occur in the transitional area between the Northern Agricultural and pastoral zone of the Gascoyne-Murchison. The species under these recovery plans *are Eremophila rostrata, Eremophila viscida, Caladenia elegans, Eucalyptus crucis subsp. Praecipuapraecipua* and *Hypocalymma angustifolium* subsp. *longifolium*.

There are also a number of plant species that are listed as threatened under the Australian Government *EPBC Act, 1999* as shown in Table . The complete list can be viewed in Appendix V.

Table 9: Plant Species Found in the Rangelands as Listed in the *EPBC Act, 1999*.

Conservation Category (*EPBC Act*)	Number of Plant Species (Whole-of-Rangelands)
Extinct	1
Critically Endangered	3
Endangered	6
Vulnerable	15

Terrestrial Threatened Fauna

The protection of threatened fauna (terrestrial) is also provided for under the *Wildlife Conservation Act 1950.* Processes for determining and listing threatened fauna undr the Act are similar to those for TECs and threatened flora. Many fauna species have become extinct at State and regional scales since 1826 due either to direct impacts of European settlement such as hunting, land clearing and resource modification, or through indirect means such as the introduction of invasive plants and animals (Abbot, 1997). Some of the highest rates of extinction for mammals have occurred in the arid areas of the Rangelands (**Figure** 11). This is probably a reflection of the cessation of Aboriginal burning, predation by foxes and cats, climatic change and habitat destruction by rabbits (Abbot, 1997). Of particular interest in terms of extinction is the presence of megafauna relics found on the Nullarbor Plain, which is important to preserve for historical reference and research purposes.

The impacts on some terrestrial fauna have reduced their number and population size to the extent where they are in need of special protection under the *Wildlife Conservation Act 1950*. In addition to these species, new species of fauna, including invertebrates, are continually being described and in some cases are likely to be classified as being rare and/ or threatened and in need of protection.

For the purpose of the Rangelands NRM Strategy, the formal threatened fauna and informal priority fauna lists have been divided into terrestrial, aquatic and marine components. The complete lists can be found in Appendix V – Threatened and Priority Fauna Lists for the Rangelands NRM Region. Table 10 summarises terrestrial threatened and priority fauna by NRM sub-region and for the whole of the Rangelands.

Table 10: Summary of Terrestrial Threatened and Priority Fauna for the Rangelands NRM sub-regions and the Rangelands NRM region as a whole.

Note that the totals for threatened and priority fauna species are not equivalent to the sum of the sub-region as species may occur in more than one sub-region

WA Wildlife Conservation CodeAct	Kimberley	Pilbara	Goldfields-Nullarbor	Gascoyne-Murchison	Whole-of-Rangelands
Extinct (E)	2	4	7	7	10
Critically Endangered (CR)	22	0	0	6	27
Endangered (EN)	9	2	5	7	16
Vulnerable (VU)	18	21	18	23	58
Priority 1 (P1)	11	5	0	8	23
Priority 2 (P2)	15	6	3	5	27
Priority 3 (P3)	8	0	1	5	14
Priority 4 (P4)	16	7	14	12	30
Priority 5 (P5)	0	0	1	0	1
Other Specially Protected (S)	2	0	4	2	4

Source: CALM Threatened Fauna List

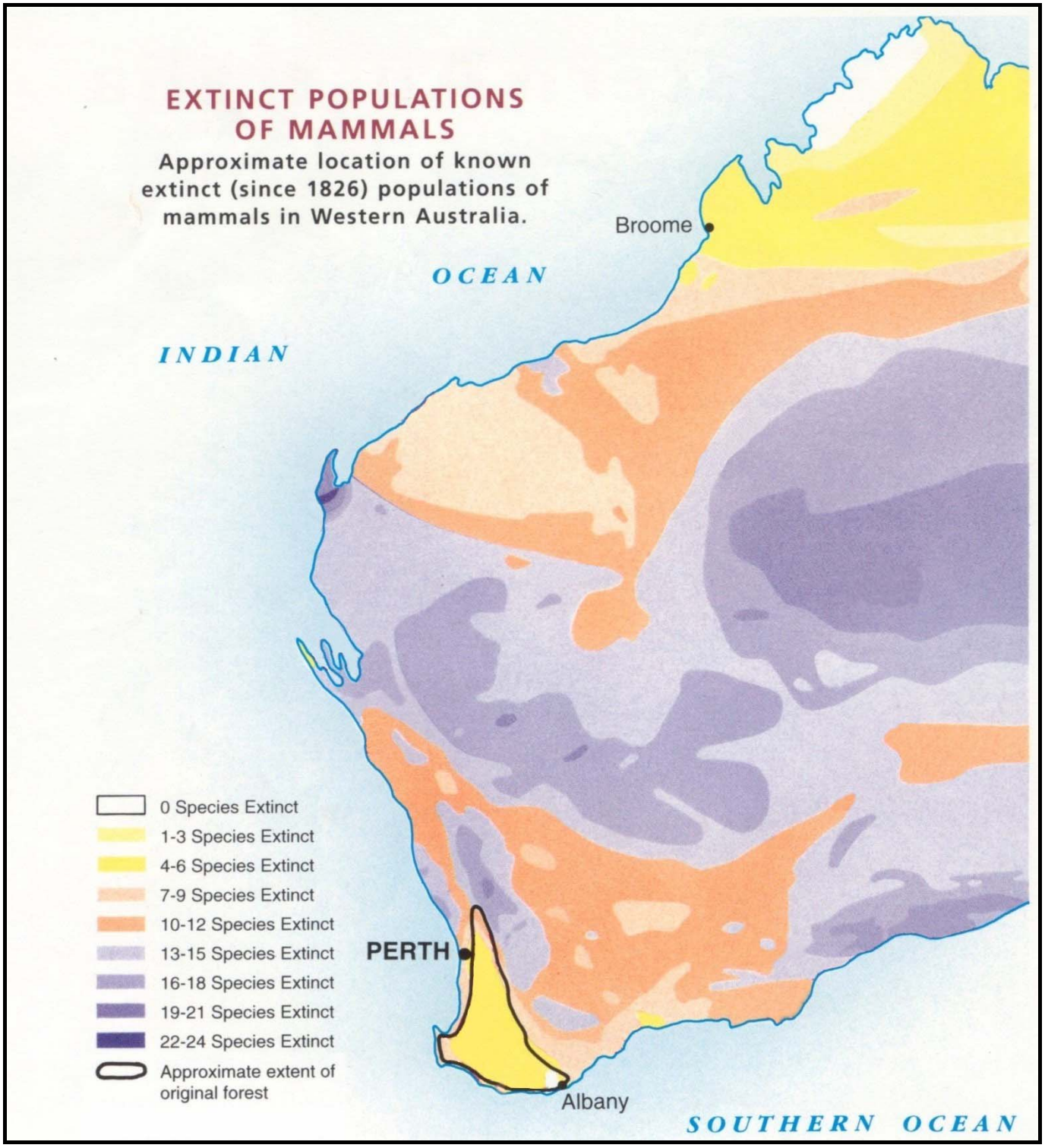


Figure 11: Map of Extinctions Compiled From Individual Species Maps.

Produced by Dr Alex Baynes (WA Museum), Dr Andrew Burbidge and Norm McKenzie (both of CALM). Source: Landscope Autumn 1997.

There are also a number of fauna species that are listed as threatened under the Australian Government *EPBC Act, 1999* as shown in Table 11. The complete list can be viewed in Appendix V.

Table 11: Fauna Species Found in the Rangelands as Listed in the *EPBC Act, 1999*.

Conservation Category (*EPBC Act*)	Fauna Category	Number of Species (Whole-of-Rangelands)
Critically Endangered	Birds	1
Endangered	Mammals	4
	Birds	5
	Reptiles and Frogs	3
Vulnerable	Mammals	14
	Birds	11
	Reptiles and Frogs	9
	Arachnids	5
	Crustaceans	1

It should be noted that all of the above State and Australian Government threatened species lists are not necessarily a true reflection of numbers of threatened species in the Rangelands. There is still much that is unknow about species in the Rangelands, with new species continually being discovered (especially flora and invertebrates) however, monitoring programs are limited. Additionally, there are inconsistencies between the State and Australian Government listing criteria and resulting lists, and significant time lags involved in the listing process.

Other Common Terrestrial Fauna

There are many terrestrial fauna in the Rangelands that are not listed on threatened fauna lists. Many of these have been described in biological studies undertaken by the Western Australian Museum and CALM. Estimates of total fauna numbers suggest that there are likely to be fauna yet to be found or described (CALM, 2004). These fauna, whilst not listed as threatened, are still reliant on natural resources for habitat and food sources. Off reserve conservation and sustainable NRM is vital to support the formal reserve system in ensuring that these more common species do not also become threatened.

2.6.8 Overview of Terrestrial Biodiversity in the Rangelands Sub-regions

Detailed information can be found in May *et al*., 2003 and CALM, 2003.

Kimberley

The Kimberley comprises the North Kimberley, Central Kimberley, Dampierlands, Victoria Bonaparte and Ord Victoria Plains IBRA 5.1 regions. It is dominated by a tropical/ sub tropical climate with the southern boundary grading into areas of the arid interior and Pilbara zone. Many features in the Kimberley make it important in terms of terrestrial biodiversity. For example, near pristine environments exist throughout the North Kimberley bioregion, which has been recognised nationally as a biodiversity hotspot, supporting essentially intact areas of flora and fauna assemblages including threatened and/ or endemic fauna (May *et al*, 2003). Of all the Rangelands sub-regions, the Kimberley has the highest number of critically endangered terrestrial species on the threatened fauna list, though only four threatened flora are listed.

Fourteen percent of the described plant taxa for the northern phytogeographic region, which covers most of the Kimberley, are endemic to Western Australia. There are several significant landscape features important for terrestrial biodiversity including Purnululu National Park, which are important for rare and endemic species and refuge attributes. Other significant geological entities include the Devonian Barrier reef systems, various ranges and gorges, and floodplains of major rivers.

There are significant karst areas in the east and west Kimberley. In the east they are found in the limestone of the Osmond, Carrboyd, Ningbing, and Weaber Ranges and the Cockburn, Dickson and Jeremiah Hills. There are also Sandstone karst areas in the Bungle Bungles. In the west karst can be found in the Lawford, Pillara, Oscar, Napier, horseshoe and Emanuel Ranges. These caves provide shelter for a large number of bat species and a high diveristy of subterranean life. They also have impressive geological diversity and play an important part in the hydrology of the area. Aboriginal cultural sites are also frequently within the entrances of the caves and in some cases are much further into the dark zone where wall paintings have been found. Sub-fossils have also recently been found inside some of the caves, the cave environment allowing their preservation over long periods of time.

Major threats to biodiversity in the Kimberley sub-region include overgrazing of native vegetation and, altered fire regimes, feral animals and exotic weeds. The region is essentially fox and rabbit-free (with the exception of Dampierland Bioregion where foxes occur) but biodiversity is subject to pressures from donkeys, camels, cats and pigs. Cane toads pose a serious threat to biodiversity due to the toxic nature of the toad and predation on other species. The front of the cane toad migration across northern Australia occurs at Victoria River in the Northern Territory. Several individual toads are known to have been found in the Kimberley on vehicles and potted plants.

The Kimberley karst is not visited as frequently as the other cave areas in the Rangelands but visitation is unmanaged and visitors and land managers are generally unaware of the fragility of the cave environment and the impact their actions could have on the systems. The karst is also under threat by mining, and there is overall a lack of acknowledgement and protection.

Pilbara

The Pilbara comprises the Great Sandy Desert, Pilbara, and parts of The Gibson Desert, Little Sandy Desert, Gascoyne and Carnarvon IBRA 5.1 bioregions. The majority of the Pilbara has an arid climate (less than 350 millimetres mean annual rainfall) and is dominated by hummock grasslands (Spinifex) and Mulga Woodlands. The Pilbara bioregion is particularly important for persisting populations of threatened and endangered fauna species such as the mulgara, spectacled hare-wallaby and bilby (McKenzie *et* al., 2003). It is also important as a centre of endemism and refugia due to numerous ranges, gorges, coastal islands and areas with geological complexity such as the Marble Bar-Nullagine mineral province.

The Great Sandy Desert bioregion is dominated by Quaternary red longitudinal sand dune fields covered with Spinifex hummock grasslands and scattered Desert Walnut and Bloodwoods. The area is rich in reptile species, particularly *Ctenotus* and *Lerista* species and there is a great likelihood of troglobitic (cave dwelling) fauna associated with calcrete systems along palaeo-drainage lines (May *et al*, 2003). This however is unsubstantiated and requires further investigation.

Significant areas for terrestrial biodiversity in the sub-region include the Chichester and Hamersley Ranges, Fortescue Plains and coastal islands such as those in the Dampier Archipelago. Desert regions are also significant due to the relatively low competition with other land uses. Barrow Island is an A Class Nature Reserve with high biodiversity values, with many threatened or restricted species, including five mammal species and a high diversity of subterranean fauna (stygofauna and troglofauna). Barrow Island also has a petroleum lease covering most of the island, which is owned by Chevron Texaco. The nature conservation values of Barrow Island are managed by CALM in partnership with Chevron Texaco.

Major threats in the Pilbara include altered fire regimes, feral animals and exotic weeds, over-grazing of native vegetation and altered hydrological regimes. The Pilbara ZCA is focusing on management of wild dogs, feral donkeys (Judas telemetry program) and camels, and introduced weeds - mainly Mesquite and Parkinsonian. Some on-ground control of declared species is also conducted. Weed action groups in the area include the DeGrey Parkinsonia and the Pilbara Mesquite Management Committee. The DeGrey Parkinsonia has funding from NLP, and carries out management of parkinsonia on the DeGrey River catchment. The Pilbara Mesquite Management Committee established in 2000, is currently funded by NHT to continue to develop and implement a strategic plan for mesquite management in the Pilbara.

The current program incorporates control and research aiming to develop best practice integrated management of mesquite using biological, chemical and fire control methods. Threats to the subterranean fauna include altered hydrology and human visitation.

Gascoyne-Murchison

The Gascoyne comprises the Carnarvon, Gascoyne, Yalgoo and parts of the Murchison and Geraldton Sandplains IBRA 5.1 bioregions and borders the Northern Agricultural district. The majority of this portion of the sub-region is within the arid climatic zone (less than 350 millimetres mean annual rainfall) but does contain reaches of the winter dominated climate zone (250 – 500 millimetres). Hence tracts of Eucalypt woodlands, which have largely been cleared for agriculture in the wheatbelt, extend into the sub-region within the Yalgoo bioregion. Yalgoo is rich in biodiversity with species that range from adjoining bioregions and with ironstone and banded iron stone ranges containing a number of threatened flora and TECs, and endemic flora and ecolofical communities that are, as yet, undescribed or have not been defined

The Western Murchison IBRA 5.1 sub-region is dominated by Mulga low woodlands and ephemeral groundcovers and contains rare calcrete aquifers and a number of rare fauna and flora. To the north the Gascoyne IBRA 5.1 region supports Mulga woodlands, *Eremophila* shrublands and areas of hummock grasslands (Spinifex). Several rare species occur in the region including Yinnitharra granite dragon (*Ctenophorous yinnietharra*), Malleefowl (*Leipoa oscillata*), Mulgara (*Dasycerus cristicauda*) and endemic species of *Eremophila*.

The coastal stretch of the Gascoyne-Murchison forms the Carnarvon IBRA 5.1 bioregion and exhibits a mosaic of saline alluvial plains with samphire and saltbush, Bowgada low woodlands and hummock grasslands. Significant terrestrial biodiversity values include Shark Bay, islands in the Shark Bay area, Murion Islands, Kennedy Ranges and refugia for endangered mammals. The North West Cape Peninsular contains more than 400 caves and other karst features. It contains three different types of limestone, which occur at different depths and each contains a unique ecosystem. The caves contain a very high diversity of troglofauna. Thirty-eight species, involving 28 families and 30 genera (10 endemic) have been collected to date. The troglobites include pseudoscorpions, spiders, crustaceans, millipedes, a cockroach, bugs, and undescribed Orthoptera (Morton *et al*, 2005). It is likely that further sampling will uncover even greater diversity within this area.

Significant threats to biodiversity in the Gascoyne-Murchison include feral animals, exotic weeds, overgrazing of native vegetation and soil erosion. Soil and vegetation loss, whilst it has not been measured, has led to a significant decline in biodiversity values. Nearly 50 percent of ground dwelling mammal fauna are now extinct (May *et al*, 2003). There has been substantial effort in the Gascoyne-Murchison to manage natural resources through the GMS. An estimated 3.4 millions hectares of pastoral leases have been purchased for addition to the formal reserve system. There has also been a major biological study (Western Australian Museum, 2000) on the southern Carnarvon Basin that described biodiversity patterning and highlighted gaps in the formal reserve system.

Key threats to the troglofauna of Cape Range come from changes to ground water levels, introduction of non-native fish species, human visitation and limestone mining (most caves lie within a Temporary Limestone Reserve) (Morton *et al* 2005). Due to the nature of karst systems, mining impacts can extend beyond the actual site of the mine.

Goldfields-Nullarbor

The Goldfields-Nullarbor comprises the Nullarbor, Great Victorian Desert, Hampton, Coolgardie, and parts of the Murchison, Little Sandy Desert, Gibson Desert and Central Ranges IBRA 5.1 Bioregions. Whilst the sub-region occurs predominantly in the arid climate zone (less than 350 millimetres annual rainfall), the western and southern margins are subject to a winter dominated climate zone (250 millimetres – 500 millimetres). The Coolgardie bioregion supports diverse woodlands rich in endemic eucalypts, with the upper landscape typically eroded lateritic duricrust with shrubs and mallees. This

bioregion is a major biogeographic interzone and reflects a regional radiation in acacias and myrtaceae, with 170 species of eucalypt occurring.

The Eastern Murchison IBRA 5.1 sub-region is characterised by internal drainage and extensive areas of elevated red desert sandplains. Numerous salt lake systems occur and the vegetation is dominated by Mulga woodlands and ephemerals. The northern margin of the sub-region consists of the Little Sandy Desert and Gibson Desert bioregions. More than forty percent of the original mammal fauna is regionally extinct in these two bioregions with 23 threatened species listed. The endangeredthreatened Marsupial Mole (*Notoryctes* sp.), Sandhill Dunnart (*Sminthopsis psammophila*), Bilby (*Macrotis lagotis*), Mulgara (*D. cristicauda*) and Great Desert Skink (*Ergernia kintorei*) occur in this area.

The Great Victorian Desert and Nullarbor bioregions dominate the central and south-eastern areas of the Goldfields-Nullarbor. The Great Victorian Desert is an active sand-ridge desert with a tree steppe of *Eucalyptus gongylocarpa*, Mulga and *Eucalyptus youngiana* over hummock grasslands, it has three recognised TECs. The Nullarbor is a basin of Cretaceous and Tertiary sediments over granite and metamorphic rocks in the north and tertiary limestone plain in the south that contain the largest arid karst system in the world as well as a large number of endemic species. The Nullarbor karst contains an impressive array of troglofauna including crustaceans, centipedes, cockroaches, beetles, spiders and pseudoscorpions. Some of these species have only been found in one cave. The bat *Chalinolobus morio* uses the caves as shelter, and they also provide nesting sites for various bird species including the cave-dwelling Nullarbor population of the masked owl *Tyto novaehollandia.* (Morton *et al* 2005) Significant megafauna fossils including the Marsupial Lion (*Thylacoleo carnifex*) have also been found in caves on the Nullarbor.

The major threatening processes in the Goldfields-Nullarbor include exotic weeds, altered fire regimes and overgrazing by stock, and native and feral animals. The feral animals of most concern to biodiversity in the region are foxes, goats, and rabbits in the pastoral areas and cats and camels in the more arid parts. A Goldfields Weed Strategy has been written to assist with strategic control across the region. Onion weed, saffron thistle, horehound and Bathurst burr are the weeds of most concern. Additionaly threats to the Nullarbor karst include alteration to hydrology, visitation, especially by inexperineced visitors, lack of management and to some degree mining. Furthermore, inappropriate management actions may also threaten the karst system. For examples actions on the surface can affect the hydrology of cave systems.

2.6.9 Major Uses and Values of Terrestrial Biodiversity

Public Conservation Use and Management

Conservation of biodiversity in the Rangelands has value for all Australians and the international community. There are many reasons for conserving biodiversity, including:

- protection of values that are rare or threatened;
- protection of environmental/ ecosystem services;
- intergenerational equity; and
- environmental ethics (the right to live).

CALM is part of the State Government's Environment and Heritage portfolio and has lead responsibility for conserving the State's rich diversity of native plants, animals and ecosystems, and many of its unique landscapes. The Government is committed to achieving conservation through establishing a formal reserve system managed by CALM that meets International Union for Conservation of Nature (IUCN) standards. Such a reserve system forms the cornerstone for conserving a representative sample of the diverse biota and associated abiotic (non-living) features of Western Australia at a sub-bioregional scale. The currently reserve covers more than 19 million hectares of the Rangelands.

To achieve such a task the principle of a "Comprehensive", "Adequate" and "Representative" (CAR) reserve system has been applied when decisions are made on additions to the reserve system. The

attributes of CAR are applied to vegetation associations described by Beard, which are being used as a surrogate for describing ecosystems. To meet CAR requirements, at least 15 percent[3] of all ecosystems should be under legislative protection (meeting IUCN management categories I or II or IV) (CALM, 2004). Table contains information on the percentage of IBRA 5.1 sub-regions and the percentage of vegetation associations that have greater than 15 percent in IUCN I – IV and section 33(2) reserves.

Whilst the principle of a CAR reserve system has its merits in theory, in reality there are limited resources and complications, such as competing land uses which make the achievement of such a system difficult. This highlights the importance of conservation initiatives on non-reserve tenure, the matrix in which the State formal reserve system exists.

Conservation on other Crown reserves is also important and can be achieved in a number of ways. Responsibility for the management of UCL and UMRs is defined in a Memorandum of Understanding (MOU) between the Department for Planning and Infrastructure and CALM. This identifies that the Department for Planning and Infrastructure is responsible for administration of UCL and UMRs and that CALM is responsible for management of fire pre-suppression planning, weed and animal control, and harvesting of flora and forest produce controls. The MOU also states, that in undertaking management, CALM will promote conservation of biodiversity and provision of sustainable multiple land use benefits. CALM only recently accepted this responsibility but is progressing in the management of UCL and UMRs through liaison with the Department of Agriculture and the Fire and Emergency Services Authority for the management of weeds, feral animals and fire respectively.

Other off-reserve conservation initiatives undertaken on private and leasehold lands include conservation covenants, voluntary management agreements, Land for Wildlife voluntary management agreements and private conservation initiatives. The latter of these has seen several properties in the Rangelands purchased by private organisations such as the Australian Wildlife Conservancy and the Australian Bush Heritage Fund and managed primarily for biodiversity conservation. All of these biodiversity conservation initiatives, including the CAR reserve system and off-reserve conservation, are faced with pressures of competing land use and limited resources.

Productive Industry Use and Management

As previously mentioned pastoral leases account for more than 90 million hectares of the Rangelands. The pastoral industry, a major commercial user of terrestrial biodiversity, relies on native vegetation for the production of livestock. Whilst in recent times there has been movement in the pastoral sector towards more sustainable practices, grazing has had a significant detrimental effect on the integrity of native vegetation and subsequent impacts on fauna, other organisms and soils. This commercial use of native vegetation for pastoral production has been realised at a significant cost to biodiversity, which is not easily measurable in fiscal terms. It must also be acknowledged that most of this historical damage was the result of ignorance of managers and government regulations of the time, rather than malice.

It is important to recognise that a concept such as biodiversity conservation, even within a pastoral context, has many benefits and values attached to it. Biodiversity, with its definition relating to genetic, species and ecosystem diversity, contributes to ecosystem resilience. Resilience reflects an ecosystems capacity to recover from stress and other forms of disturbance, with relatively intact ecosystems able to recover more effectively than degraded or simplified ecosystems. Therefore managing grazing pressure on native vegetation can lead to benefits for biodiversity and ecosystem resilience, and for the long-term viability of pastoral production.

Management of biodiversity in a pastoral context is being undertaken through initiatives such as the Ecosystem Management Understanding project (EMU); where pastoralists are working with scientists and landscape ecologists to understand and better manage the effects grazing has on elements of biodiversity and landscapes. Other initiatives include conservation under section 16(a) of the

[3] For some ecosystems it is not possible to achieve 15% due to pastoral impacts. Also some ecosystems, particularly those that are considered rare and may be of limited geographical extent, will require greater than 15% to meet the criteriacriterion of Adequacy.

Conservation and Land Management Act 1984, cooperative management in relation to fire, threatened species, and control of invasive species and the management of straying stock. It is also possible that areas on pastoral properties have limited production value but can be of benefit to biodiversity conservation. There is a need for an improved process that encourages and supports environmental stewardship by land managers. Holistic planning for multiple NRM outcomes is necessary for biodiversity conservation to succeed on lands outside the State formal reserve system.

To ensure better biodiversity outcomes from the harvesting of Sandalwood, the Forest Products Commission (FPC) has recently embarked on the implementation of the Sandalwood Enrichment Program (SEP). The SEP has similar management objectives and outcomes as EMU. Through a dead sandalwood harvesting operation conducted by the pastoralist, areas within the lease are identified for the sandalwood enrichment and protection process. The benefits associated with the harvesting and enrichment are payment to the pastoralist for harvesting dead sandalwood on the lease, provision of materials to the pastoralist from the FPC to construct protected enrichment areas, and income for construction of fences / trap yards and from captured feral goats. This should lead to greater benefits to biodiversity conservation within protected areas and the continuation of an enriched sandalwood population on the lease providing opportunities for future sustainable sandalwood harvesting.

Tourism Use

Tourism in Western Australia attracts local, national and international travellers, a significant number of whom visit to experience the State's unique biodiversity and environmental features. Tourism contributes substantially to the State's economy with many of the benefits experienced by regional businesses and nature based tour operators. For example, a report undertaken by the Cooperative Research Centre for Tourism found that in the Gascoyne Coast region, 92 percent of all visitor expenditure was due to the Ningaloo Marine Park and Cape Range National Park, representing about $127 million a year (CALM, 2004).

This example holds true for the Rangelands' other sub-region where features such as the Purnululu, Cape Arid and Karijini National Parks attract thousands of visitors every years. Visitor experiences are largely based on appreciation of, and interaction with the natural resource assets these attractions contain. Nature based tourism needs to be managed sustainably to ensure low impact occurs on biodiversity while maintaining a viable industry.

Indigenous Use and Management

Indigenous people historically have had close ties to terrestrial biodiversity spiritually, culturally and physically. Many animals and plants are important to Aboriginal culture and have spiritual significance. Additionally, many cultural practices have had an influence on terrestrial biodiversity through Aboriginal history (eg traditional burning). Many of these cultural practices, values and knowledge are at risk of being lost due to the breakdown of Aboriginal society as a result of European occupation.

Approximately 20 million hectares of reserve and leases are currently managed by Indigenous communities. The Government has released a proposal for joint management for some current, and any future, conservation reserves between CALM and Aboriginal bodies for the purpose of conservation of biodiversity and cultural heritage. For example, Purnululu National Park in the Kimberley. The Demonstration Park Council program, developed by CALM, aims to establish councils consisting of Aboriginal Traditional Owners and CALM officers to prepare draft and final management plans (or participate in revising and/ or implementing already established plans), with the council having a role in considering matters relating to Aboriginal use and involvement.

2.6.10 Major Threats to Terrestrial Biodiversity

Terrestrial biodiversity is in decline at a national level (ABS, 2004) and this is also true for the Western Australian Rangelands. At the root of the problem are productive industries, urban development, infrastructure and extractive industries. These in turn lead to secondary threatening processes such as

inappropriate fire regimes, predation and competition by exotic animals and plants on native species, alteration of soil and hydrological processes, introduction of diseases and the direct use of native species for recreational or commercial purposes.

It should be noted that in many areas, and for many threatened species and communities, the threats causing biodiversity decline are unknown.

Following is an overview of the major threatening processes affecting biodiversity in the Rangelands.

Physical Disturbance

Fire

In recent history there has been increasing incidence of large, intense fires in certain parts of the Rangelands. This fire regime is different to what we know of fire regimes in pre-European times where there were more frequent smaller fires producing a patch-burn mosaic. There is a paucity of knowledge on the effects of the change in fire regimes on biodiversity in rangeland/ tropical savanna environments, though research is being conducted such as the Bushfire CRC with the Burning for Biodiversity project in the Territory Wildlife Park.

It is thought that for ecosystems dominated by Spinifex grasslands, a prescribed burning system that creates heterogeneity in burn history and vegetation structure throughout the landscape would be most desirable for maintaining and encouraging biodiversity (Burrows *et al*, 1991).

There is evidence that large uncontrolled fire is significantly affecting the relative proportions of fire dependant and fire sensitive vegetation assemblages, to the detriment of the latter. This is particularly the case in Spinifex dominated arid zoneszone and the tropical savannas of the Goldfields-Nullarbor, Pilbara and Kimberley. High seasonal growth in the North Kimberley also leads to a fire prone environment and there is a need for greater fire management. In areas such as the Gascoyne-Murchison, uncontrolled fire is less prevalent due to the low structure and distribution of the fuels and the fuel loads from reduction effect of pastoral gazing. However, this can have detrimental effect for species that are fire dependant.

Unsustainable Grazing

Grazing of domestic and feral stock and some native macropods (occurring in greater than natural numbers) directly affects the composition and cover of native vegetation. This in turn can lead to the introduction and/ or spread of undesirable plant species and a loss of topsoil. Changes in composition and density of native vegetation can have direct effects on other species that rely on vegetation for food or habitat.

Excessive grazing pressure from both domestic stock and feral species, such as rabbits has been implicated as a factor in mammal species extinctions and on-going decline of extant mammal, bird and plant species and threatened ecosystems (Fisher *et al*., 2004).

When measuring the impact of grazing in the pastoral sector, the total grazing pressure needs to be determined to effectively alter stocking rates so that a sustainable carrying capacity can be maintained. The term “sustainable” needs to be used in the context of the management objective, as “sustainable” in terms of productivity and “sustainable” for biodiversity outcomes are not necessarily the same.

Clearing and Habitat Disturbance

Vegetation clearing, is another form of physical disturbance and although not widespread, appears to be increasing within the Rangelands. It has particular relevance to urban development, irrigation areas and extractive industries such as mining. Additionally vegetation clearing is associated with mining for infrastructure corridors and can have significant impacts in terms of fire regimes (and increased

frequency) and drainage shadows. Roads and rails also have impact creating drainage shadows and ponding. Mining, altered hydrology and human visitation can all cause physical disturbance to karst environments and negatively impact on the residing flora and fauna.

Clearing has immediate impacts on biodiversity as it removes sources of habitat and food. It also has the potential for off site impact to occur as vegetation in most cases provides stability for soil structures and hydrological balances.

Habitat degradation occurs as a result of physical disturbances, which can impact on the integrity of ecosystems and ecosystem processes leading to a lower quality of habitat. Evidence of this can be seen in the number of extinctions that have occurred since European settlement in Western Australia. Up to 24 species of mammals have become regionally extinct in some areas of the Rangelands (Abbot, 1997).

Introduced Plants, Animals and Organisms

Exotic plants come from several sources including household gardens, agricultural and pastoral species, grain and stock imports. Exotic plants threaten biodiversity by competing for essential light, water and nutrients. Often they are opportunistic species that can establish very quickly in disturbed areas.

The Australian Government National Weeds Strategy was developed in 1997 (revised 1999) to address weeds at a national level, in particular:

- weed problems which threaten the profitability or sustainability of Australia's principal primary industries;
- weeds problems which threaten conservation areas or environmental resources of national significance;
- weed problems where remedial action may be required across several States and Territories; and
- weed problems which constitute major threats to Australia's biodiversity.

Weeds of National Significance that occur in the Rangelands include:

- Parkinsonia;
- Mesquite;
- Salvinia; and
- Rubber Vine
- Prickly Acacia (*Acacia nilotica*).

The State Government released the *Environmental Weeds Strategy for Western Australia* in 1999 and the *Weed Plan for Western Australia* in 2001. The Weeds Strategy contains 16 recommendations for the strategic management of environmental weeds in the State in the areas of:

- integrated environmental weed management;
- control methods;
- monitoring and evaluation;
- coordination and integration;
- roles and responsibilities;
- resources; and
- public awareness and community involvement.

The strategy also lists 1,350 environmental weeds, 34 of which are rated high. Of these high rated environmental weeds, species such as mimosa bush (*Acacia farnesiana),*Mimosa (Mimosa Pigra) kapok bush (*Aerva javanica*), buffel grass (*Cenchrus ciliaris*), passion vine (*Passiflora foetida*) and African boxthorn (*Lycium ferocissimum*) occur in the Rangelands.

The Weed Plan consists of a number of components similar to the Environmental Weeds Strategy that aim to provide direction from policy through to site based management of weeds.

There can be instances where conflicts arise between productive land use and biodiversity conservation in relation to introduced plant species. For example buffel grass, which is widespread throughout the Region is used for soil stabilisation, dust suppression and reducing erosion and provides significant productivity benefits to pastoralists but is also an environmental weed of concern. It can also have a secondary impact of increasing the frequency and size of wildfires. Therefore in the case of species such as buffel, where its wholesale removal is probably impractical, management solutions are needed that provide outcomes for productivity and biodiversity. There may however, be particular circumstances where eradication of invasive species in localised areas is necessary to protect high value biodiversity assets.

Exotic animals have been introduced either intentionally or by accident by Europeans during the past 200 years. They include sheep, cattle, goat, dog, rabbit, fox, cat, pig, horse, black rats, common mouse, cane toads, fresh water fish and a range of invertebrates. Exotic animals threaten biodiversity by either competition for resources, predation of native species or physical damage (such as hoofed animals or toxic effects). By far, the greatest damage to vertebrates has been caused by foxes and cats (though foxes generally are not present in most areas of the Kimberley), which have significantly contributed to the level of extinction in recent history (Abbot, 1997). Also hollow dwelling animals have been subject to competition for hollows by feral bees. Due to the low numbers of predatory native animals, other native species have not evolved life histories to avoid predation by carnivores such as the fox and cat. Exotic animals have been particularly damaging to biodiversity because of their mobility and the loss of habitat that they can cause.

Disease can also threaten native plants and animals but is not known to have had a wide impact on the biodiversity of the Rangelands. However there is potential for this to occur, which could have devastating effects.

Problem Native Species

Due to the change in natural systems, the populations of some native species have fluctuated to levels that are causing undesirable effect on other components of biodiversity. For example, the increase in artificial watering points in pastoral land has lead to substantial increases in kangaroo numbers, causing adverse effects on native vegetation in some areas. Similarly, grazing pressure and fire can lead to increases in native plant species such as Bardi Bush (*Acacia victoria* group).

Other native plants can become a problem as a result of choice of species for revegetation, especially in mine rehabilitation, but also in amenity plantings and Rangelands rehabilitation projects. This can lead to introduction of non-provenance species and thus have an impact on the genetics of local populations.

Altered Biogeochemical Processes

Biogeochemical processes are defined as "*the chemical relationship between an organism and their environment*". For example, the decomposition of leaf litter returns nutrients to the soil to be used again. In a situation where this process has been altered, such as under excessive grazing, the return of nutrients to the soil is reduced, lowering the growth capacity of plants. Changes to the chemistry of the physical environment, such as increasing soil salinity, can have adverse effects on organisms that interact with that environment. The maintenance of the integrity of soil structure is critical to these processes.

Pollution

Pollution directly impacts on biodiversity by introducing substances at toxic levels. This can lead to a lowered capacity, or in extreme cases, complete destruction of native species in localised areas such as where acid rock drainage from mine sites or chemical spills along infrastructure corridors might occur.

Generally pollution occurs in restricted and isolated cases and is not considered a wide-ranging threat within the Rangelands, though it may be important at smaller scales.

2.6.11 Current Management of Terrestrial Biodiversity

Additions to the State's Formal Reserve System

The State Government is a member of the IUCN. This is an international body that has set international categories for the conservation of nature through the World Commission of Protected Areas (WCPA). In support of this, CALM aims to establish a reserve system that meets IUCN categories I, II or IV. Land can be directly purchased for addition to the reserve system. The attributes of the proposed purchase are assessed to determine the quality of biodiversity and what value it will add to meeting CAR requirements. An estimated 3.4 million hectares of pastoral land were purchased for addition to the reserve system through the GMS. This significantly added to the representation of Southern Rangelands ecosystems within the reserve system.

However, the representation of Rangelands ecosystems in the reserve system is still relatively low compared to ecosystems reserved in the southwest. Recent initiatives of the State Government have seen changes in the leasing arrangements of some pastoral lands. This includes identification of pastoral properties from which land is to be excluded from leasing arrangements and added to the reserve system progressively up to 2015. Currently there is more than 19 million hectares in Rangelands reserves including national parks, nature reserves, conservation parks, miscellaneous reserves and pastoral lands managed under section 33(2) of the *Conservation and Land Management Act 1984*. These reserves and national parks are managed primarily for the conservation of biodiversity. Where resources allow, active restoration of biodiversity is on-going, particularly where land has been acquired in a degraded condition.

Issues such as multiple uses of conservation areas will also need to be assessed during the expansion of the State reserve system.

World Heritage Areas

There are two World Heritage Areas within the Rangelands that have been inscribed on the World Heritage list. The Shark Bay World Heritage Area was established in 1991 on the basis of its natural heritage value. A management plan for terrestrial reserves was completed in 2000, setting out management objectives and action for reserves.

Purnululu National Park was nominated for listing based on natural and cultural values and received World Heritage Listing in 2003 for natural heritage values. Inscribing for cultural significance has been delayed until 2005 while the Western Australian Government provides further information to demonstrate that management plans provide scope for sustaining Aboriginal communities within the park.

The Nullarbor Plain has been investigated for suitability at a preliminary stage several years ago and prior to the recent megafauna sub-fossil find and discovery of many other unique values.

There are plans for the Ningaloo area to be nominated in the near future. Further information on the Ningaloo area can be found in the marine biodiversity section.

Indigenous Protected Areas

Indigenous Protected Areas (IPAs) are an initiative under the Department of Environment and Heritage. The IPA program is part of Australia's National Reserve System Program, which aims to establish a network of protected areas that includes a representative sample of all types of ecosystems across the country. The National Reserve System Program is itself a part of the Australian Government's Natural Heritage Trust.

With support from the IPA program, Indigenous landowners commit themselves to manage their lands for the protection of natural and cultural features in accordance with internationally recognised standards and guidelines.

To date, 13 IPAs have been declared over Aboriginal land, covering more than 3.1 million hectares and adding significantly to the National Reserve System. The IPA program funds management plans and practical work to protect natural and cultural features and to contribute to conserving biological diversity (http://www.deh.gov.au/Indigenous/fact-sheets/ipa.html).

Private Conservation

Private landholders are able to access funding through a variety of sources, such as the Australian Government Envirofund, to assist in conservation work on private land. To date, the Rangelands community has not taken full advantage of such funding sources. There are some community members working towards ecological sustainability within their enterprises however, information on their activities and progress has been difficult to obtain for inclusion in the Strategy.

Threatened Species and Communities Management

CALM oversees the recovery and management of threatened species and ecological communities. These are taxa and assemblages that are threatened with extinction. Management is implemented through the development and implementation of recovery plans and Flora Wildlife Management Programs. However, only 30 percent of threatened taxa and 40 percent of ecological communities have plans in place (CALM, 2004).

Project Eden in the Shark Bay area is one of the largest and most exciting arid zone recovery programs in Australia. It aspires to reintroduce mammal species that have reduced populations or are locally extinct, remove unnatural threats and rehabilitate areas on 105,000 hectares of Peron Peninsula. Historical evidence shows that prior to European settlement there were more than 20 species of mammals living in this area and that within less than 200 years this number has been reduced to less than seven.

In the Ningbing ranges north of Kununurra, East Kimberley a Camaenid land snail threatened species project is currently being undertaken by CALM.

Non-government Conservation

The Threatened Species Network (TSN) is a community-based program of the Australian Government's Natural Heritage Trust and WWF-Australia. The role of the TSN is to support community groups undertake on-ground threatened species conservation work. The TSN administers the TSN Community Grants program, through which 13 projects have been funded throughout the Rangelands to a value of $934, 062. This has initiated ongoing work such as the Ningaloo Marine Park-Marine Turtle Community Monitoring Program (Cape Conservation Group), Freshwater Sawfish survey and education project in the Kimberley (Kimberley Land Council), and conserving rock wallabies in the Calvert Ranges (Jigalong Community Inc).

The Australian Wildlife Conservancy (AWC) and the Australian Bush Heritage (ABH) Fund are also involved in on-ground biodiversity conservation in the Rangelands. The ABH fund purchased White Wells Station in 2003 which covers 68,600 hectares of eucalypt woodlands, wildflower-studded sand plains, natural salt lakes and heathlands typical of vegetation common to the wheatbelt.

The AWC fund has purchased two pastoral leases in the Rangelands, Mt Gibson Station in the Gascoyne-Murchison area and Mornington Station in the Kimberley. AWC established these sanctuaries for the protection and restoration of native animals and is also involved in reintroduction programs association with Faure Island in Shark Bay. It has also recently entered into negotiations with

the Ningaloo pastoral lease to establish a wildlife management and introduction programme on the property.

The Indigenous owners of Ninghan Station have recently excluded approximately 50,000 hectares of their pastoral lease for the benefit of biodiversity conservation. Ninghan Station shares its boundary with White Wells Station and Mt Gibson Station and as such provides a significant gain in biodiversity conservation for the Region.

There are many other community and conservation groups across the Rangelands, such as the Northern Australian Environmental Alliance and Kimberley Kleanup, which play an important role in the conservation of terrestrial biodiversity.

Environmental Campaigns

There are a number of campaign organisations such as the Wilderness Society, Conservation Council and Environs Kimberley highlighting areas of biodiversity and the environment that they consider are at threat or of particular importance. Programs of relevance to the Rangelands include the Wilderness Society's Wild Country Cape to Kimberley and Gondwana Link campaign, several campaigns undertaken by Environs Kimberley, and the Conservation Council's Save Ningaloo Reef and Rescue Barrow Island campaigns.

NHT Priority Projects

A number of priority projects have been funded through NHT in the interim period between NHT and the extension of NHT, including ecologically sustainable rangeland management in the southern Rangelands (Roderick River Restoration Project), Kimberley Regional Fire Project, environmental management in the Ord catchment area, the Pilbara Bioregion Biological Survey and the Shark Bay World Heritage Area. All of these projects address the conservation and better management of biodiversity.

2.6.12 Terrestrial Biodiversity RCTs and MATs

RCT6: By 2025, maintain or improve vegetation community composition, structure and function in priority areas/ landscapes against standards to be developed by 2008

RCT7: Maintain or improve the current (2005) conservation status of terrestrial native species and assemblages by 2025

RCT8: The comprehensiveness, adequacy and representativeness (CAR) of all ecosystems in formal protected areas is improved on a priority basis by 2015, compared to the CAR reserve Analysis 2003

RCT9: Eradicate, or reduce the abundance and distribution of, ecologically significant invasive or pest species by 2025 and limit new occurrences or introductions

Management Action Targets	Geographic Focus	Actions	Potential Partner Groups	Links to RCTs	Priority
Benchmarking & Monitoring					
12  **L22.** By 2012 the region's conservation landscape and biodiversity values and associated threatening processes have been identified, characterised and prioritised	Priority Areas	• Identify and prioritise using trade-off analysis key threatening processes on native species • Support the completion of biological inventory such as the Pilbara and Kimberley Islands biological surveys using regional specific standards for all biological surveys • Biodiversity priority areas and landscapes for management identified through incorporating community knowledge • Collate traditional knowledge systems and existing information • Investigate, research and database the distribution, abundance and ecological requirements of flora and fauna populations in priority areas for management purposes by 2010 • Increase research (scientific and ethno-ecological) into population status, pressures and protection mechanisms for threatened species and threatened ecologically important communities • Undertake taxonomic studies to resolve problems within ecological important species groups and complexes • Develop and implement a protocol for indigenous engagement in biodiversity monitoring and research	State NGOs Research Industry Community Traditional Owners	RCT1 RCT2 RCT6 RCT7 RCT9	1A

Management Action Targets		Geographic Focus	Actions	Potential Partner Groups	Links to RCTs	Priority
12 	**L23.** By 2010, trend indicators and reference sites identified to monitor priority ecosystems, species and communities' status	Regional	• Indicators developed • Regional monitoring systems for biodiversity priority areas, identified in Biodiversity Audit 2002 • Review Biodiversity Audit • Review the adequacy of current and proposed formal reserves for protection of priority fauna habitats and vegetation communities • Research CAR system design options for preserving Rangelands biodiversity	State NGOs Industry Community Traditional Owners	RCT6 RCT7 RCT8 RCT9	1A
2 	**L24.** By 2008, develop a framework for measuring vegetation condition (based on structure, composition and function)	Regional	• Investigate existing vegetation indices to determine relevance. Develop vegetation index to assist in developing best practice guidelines • Establish vegetation resource condition targets and management action targets by 2008 • Undertake native vegetation mapping to improve the scale of mapping from 1:250,000 to 1:100,000, with an initial focus on the current reserve system, by 2010 • Establish consistent method for vegetation mapping • Establish schedule for mapping on priority basis • Undertaking mapping using a combination of remote sensing and on-ground truthing	Research State Government Industry	RCT5 RCT3 RCT6 RCT7 RCT8	1A
2 	**L25.** Investigate potential impacts of climate change on biodiversity by 2012	Regional	• Undertake research to provide a greater understanding of the impact of climate change on native species and ecosystems and management options to address these threats • Engage in research and collaborating with research organisations and programs already underway • Model ecological impacts • Model adequacy of reserve system to allow species migration • Identify measures to conserve species likely to be at threat from climate change • Incorporate findings of climate change impact study into management plans for priority conservation areas	State Industry NGOs Research	RCT6 RCT7	1B

Management Action Targets		Geographic Focus	Actions	Potential Partner Groups	Links to RCTs	Priority
On-ground Actions						
7 	**L26.** By 2010, 20% of those vegetation types in each IBRA 5.1 region that are currently inadequately-represented in protected areas have at least 5% of their area within the formal reserve system in an effort to move towards the minimum CAR requirement of 15%	Regional Priority Areas	• Prioritisation of vegetation types for acquisition according to representation in CAR reserve system. • Incorporate all current proposed conservation reserves into CAR system, were suitable management can be applied • Replicate conservation areas within a vegetation type where possible • Undertake negotiations for acquisition. • Acquire and develop management plans for new areas • Acquire priority areas for addition to CAR reserve systems and develop management plans on priority basis. • Review the adequacy of current and proposed formal reserves for protection of priority fauna habitats and vegetation communities • Research CAR system design options for preserving Rangelands biodiversity	State Federal Industry Community	RCT8	2A
2 	**L27.** By 2010, all vegetation types under-represented in the formal reserve system will have at least 5% managed for biodiversity outcomes off reserve as part of a property management plan	Priority Areas "Biodiversity Hotspots"	• Identify alternative economic use of vegetation to maintain stewardship of land and provide management advice • Include off-reserve land management opportunities through the provision of incentive programs to manage native vegetation eg extension of covenanting programs for leasehold lands, tax rebates, stewardship-co-management programs, development of management agreements • Identify priority areas of vegetation for protection / rehabilitation in off-reserve areas e.g. focal species approaches and landscape recovery models	State Research Community groups Traditional Owners Local Federal NGOs Industry	RCT6 RCT7	1A
2 	**L28.** By 2010 feral herbivores are managed to reduce the impact in and around all highly impacted biodiversity conservation reserves	Reserve System UCL and UMRs	• Manage grazers in conjunction with surrounding land managers. Develop programs to manage feral grazers • Use Total Grazing Management infrastructure to remove feral and domestic breeds in reserve systems	Research institutions NGOs Traditional Owners State agencies Local Government Industry	RCT5 RCT6 RCT7 RCT9	1A

Management Action Targets		Geographic Focus	Actions	Potential Partner Groups	Links to RCTs	Priority
12 	**L29.** Implement processes to prevent further degradation to priority karst systems by 2010	Priority Areas	• Prioritise karst systems for action • Educate land managers and the public about causes of cave damage and appropriate behaviours. • Establish appropriate eco-tourism infrastructure e.g. interpretive centre, within-cave cameras • In collaboration with interested stakeholders (including cross-regional stakeholders), develop and implement cave management plans • Support World Heritage listing for Nullarbor karst and Cape Range and promote awareness of the implications and opportunities. • Review research into cave ecology, hydrology and management and address gaps. • Identify and compile a complete inventory of karst features through out the Rangelands and classify/grade in accordance to their biological and social values.	Research institutions NGOs Traditional Owners State Local Government Speleologists Industry	RCT5 RCT6 RCT7 RCT8 RCT1 RCT2	1A
7 	**L30.** Conduct coordinated feral predator control program to reduce the impacts of predation on native fauna populations across four priority landscapes by 2010	Reserve System	• Identify priority areas for predator control programs • Implement predator control programs across all land tenures with support from all stakeholders in priority areas • Research more effective and efficient methods for predator control including feral animal dynamics and impacts on fauna eg cats • Reintroduction of missing animals – management programs developed in conjunction with cat and fox control • Ensure adequate staffing and resources for starling control program	Researchers State Government Local Government Federal Government Community groups NGOs Traditional Owners	RCT9	2B
7 	**L31.** By 2009, innovative control methods developed and implemented to halt the entry of cane toads into the northern Rangelands	Northern Rangelands	• Trial innovative control methods for halting cane toad entry into the Kimberley • Identify the impacts of cane toads on significant species • Undertake surveys and investigations to determine and prioritise species under cane toad threat • Develop strategies for the protection of species (such as ex-situ conservation actions) likely to be under threat from cane toads • Implement conservation strategies for the protection of species • Monitor and evaluate the impact of cane toads on the in-situ status of species at risk	Federal State Industry Community Traditional Owners NGOs	RCT7 RCT9	2B

Management Action Targets		Geographic Focus	Actions	Potential Partner Groups	Links to RCTs	Priority
2 	**L32.** 50% of land managers are implementing approved fire management plans incorporating biodiversity conservation objectives by 2009	Regional	• By 2007 the fire ecology of the Rangelands is better understood and fire management plans are developed and implemented for priority fire management units • Identify and prioritise suitable management units based on land use and ecological attributes • Identify appropriate fire regimes and fire management practices as appropriate for different land systems using traditional and contemporary tools • Best Practice fire regimes developed • By 2007 there are fire management plans (including Wild Fire Threat Analysis) developed and/or implementation continued for all ecologically sensitive areas including Cape Spinifex grasslands, threatened species critical habitats and other significant areas • Fire plans take into account biodiversity conservation planning • Cooperative fire management planning is achieved between neighbouring land managers • Engage with stakeholders to achieve common outcomes in regards to fire management	Federal State Industry Community Traditional Owners NGOs	RCT6	1B
2 	**L33.** By 2008 management plans are in place and implemented for all protected areas (Reserve system, IPAs, etc) by 2010	Regional	• Develop management plans • Implement priority actions and source necessary funding • Engage all stakeholders in the management of protected areas (including formal reserves, off-reserves and Indigenous Protected Areas) • Improve areas acquired for reserve systems and off-reserve land under long term management • Monitor and evaluate areas for adaptive management	State Government Community Industry Group Research institution Traditional Owners	RCT1 RCT6 RCT7 RCT9	1B

Management Action Targets		Geographic Focus	Actions	Potential Partner Groups	Links to RCTs	Priority
7 	**L34.** Improve the conservation status of 30% of threatened species and ecological communities by 2010	Regional Priority Areas	• Review and prioritise species requiring interim recovery plans • Development of Recovery Plans for threatened species and threatened ecological communities where needed • Make necessary nominations for addition to threatened list • Develop threat abatement plans • Development habitat management plans for significant species and communities (e.g. regionally endemic, migratory or iconic species) • Develop models for threatening processes affecting priority significant species and ecological communities • Develop, in collaboration with Traditional Owners breeding and propagation programs for threatened and endangered species • Review the implementation status of existing threatened species recovery plans • Prioritise actions within new and existing plans for implementation • Conduct research into priority flora and fauna to determine status • Make necessary nominations for addition to threatened list • Implement threat abatement plans • Implement a study on the status of threatened species of national significance on offshore islands • Identify islands and species suitable for establishing refuge populations. • Continue the implementation of recovery plans eg. Project Eden, Western Shield • Write, review and/or revise management plans for utilised species such as sandalwood and fire wood species adjacent to major population centres and communities • Establish breeding and propagation programs for threatened and endangered species as appropriate	Federal Government State Government Research institutions NGOs Traditional Owners	RCT7 RCT6	2A

Management Action Targets		Geographic Focus	Actions	Potential Partner Groups	Links to RCTs	Priority
Institutional Frameworks, Planning and Policy						
11 	**L35.** Identify institutional changes to assist in achieving off reserve conservation outcomes by 2005/ 2007	Regional	• Significant ecological communities will be cooperatively managed for biodiversity outcomes through successful negotiation in off reserve areas. • Develop and trial a stewardship program • Change agency policy to accommodate stewardship program • Change agency policy to accommodate community and stakeholder involvement in the implementing, monitoring and evaluating recovery programs • Develop and trial a stewardship and incentives program to manage for biodiversity outcomes in off reserve areas • Continue to accommodate community and stakeholder involvement in the implementing, monitoring and evaluating of recovery programs	State Local Government Industry NGOs Traditional Owners	RCT6 RCT7 RCT9	1B
11 	**L36.** Implement joint management arrangements on 5 conservation reserves by 2010	Regional	• Management Joint management plans for conservation land developed • Conservation Land management is done in partnership with Traditional Owners, community groups and other land managers eg. Demonstration Park Councils • Identify priority areas for Joint management arrangements	State Industry Traditional Owners NGOs	RCT6 RCT7 RCT8 RCT1 RCT2	1B
12 	**L37.** Develop a strategy for significant ecologically invasive or pest species control in high priority biodiversity areas by 2010	Regional	• Management Plans Developed • Promote the establishment and enhancement of bodies to co-ordinate weed and feral animal control activities across all tenures eg. Extend and enhance ZCA model • Develop mechanisms to ensure that the commercial harvesting of feral animals has maximum biodiversity and NRM benefits	State Industry NGOs Traditional Owners Local Government Community	RCT1 RCT9	1B

Management Action Targets		Geographic Focus	Actions	Potential Partner Groups	Links to RCTs	Priority
Education, Awareness and Further Engagement						
11 	**L38.** Develop an education process for pastoral land holders on improved native vegetation management by 2007 with a land mangers uptake of 25%	Regional	• Develop a number of educational options • Tool box developed to encourage sympathetic land uses for biodiversity outcomes • Identify methods of ecologically sustainable grazing management to achieve accreditation of property • Identify delivery mechanisms and employ appropriate implementation team • Increase awareness of potential of kangaroos as a commercial resource • Ensure traditional management and resource use practises are incorporated in education programs • Education of recommendations for best fire management practices with a focus on biodiversity conservation • Land managers accessing regularly fire information on websites • Educate public on best fire management practises	State NGOs Community Schools Local Government Industry Traditional Owners	RCT6 RCT7 RCT9 RCT1	1B
11 	**L39.** At least 30% of tourist operators have completed a course that raises their awareness of environmental management by 2008	Regional	• Tourism training programs developed and implemented • Training programs to include traditional knowledge • Mentoring of Aboriginal tour operators • Tour operators accredited • Leave no Trace - Educate visitors on camping etiquette • Signage and information campaigns to raise awareness of sustainable tourism • Identification and participation with Indigenous community • Implementation of the Kimberley Sustainable Tourism Project by 2006 • Investigate tourism options for Indigenous lands • Include NRM issues and outcomes when developing material for self drive tourists	Tourism Industry, main Main roads, Shires, LCDCs, DoE, CALM, DEH Traditional Owners Schools Community NGOs	All	1B
	See MAT L17					

Management Action Targets		Geographic Focus	Actions	Potential Partner Groups	Links to RCTs	Priority
Cultural Heritage						
7 	**L40.** Establish sustainable harvesting protocols for commercial use of native species by 2010	Regional	• Research and experimentation to identify sustainable use for a range of bush products • Protocols developed • Encourage publication of Aboriginal seasonal calendar– what is eaten, can be eaten and when, including natural resource harvesting – annually • Bush tucker nurseries	State Traditional Owners Community NGOs Industry	RCT1 RCT2	2B
	See MATs L18, L19 L21					

2.6.13 Air Quality

Air quality is an issue of concern for some communities in the Rangelands, particularly the Northern Rangelands and the Goldfields. Research shows that air pollution can adversely affect human health and the environment.

Pollutants are emitted to the air from various sources including the combustion of wood and fossil fuels (eg coal, petrol and diesel), emissions of hydrocarbons from oil and gas refining, odours from industrial processes or intensive agriculture, transport networks, planes for tourism and dust associated with mining and land clearing. When these emissions are discharged during periods of poor dispersion, or conditions conducive to smog formation, episodes of poor air quality can result.

Regional areas can also experience poor air quality caused by natural sources such as bushfires and windblown dust, or by man-made sources such as industrial facilities and hazard reduction burns.

2.6.14 Current Management of Air Quality

Through the National Environment Protection Council (NEPC), the Australian, State and Territory Governments set air quality standards for six major air pollutants:

1. carbon monoxide;
2. nitrogen dioxide;
3. photochemical oxidants;
4. sulfur dioxide;
5. lead; and
6. small airborne particulates.

These standards are part of the National Environment Protection Measure for Ambient Air Quality, or Air NEPM. The standards for the Air NEPM were established on the basis of scientific studies of air quality and human health from all over the world. Whilst the standards are intended to apply at large population centres, they will generally be applied as targets by the regulator and most industries in the Rangelands.

Whilst natural sources are difficult to control, undertaking sustainable land management practices can contribute to mininising negative air quality. Collaborative projects, such as the NHT funded Kimberley Fire Project, aim to share information and draw together management initiatives that improve fire management practices whilst reducing the negative impacts to air quality as one of the benefits. Similarly, effective land management initiatives such as the NHT funded EMU project and LCDC and private pastoral activities can limit sources of dust.

Managing community expectations for dust management, particularly at ports, must consider optimal use of scarce water resources and development of best practice management practices. Often there is a poor understanding of the connection between the use of water for dust management and the pressure this additional usage may have on the ecosystems where the water is abstracted.

Environmental Protection Authority ministerial conditions, Department of Environment instruments and industry Dust Management Plans are used to help control the cumulative effects of dust. Companies and the regulator will be encouraged to adopt the NEPM Air standard for particulates, derived as a guideline for monitoring and reporting, as a target for dust emissions. Iron ore dust is a significant amenity issue in some locations. Whilst there are some major initiatives to reduce dust, the scale of throughput and lack of adequate buffer zones compound the problem.

Hydrocarbons and other industrial emissions occur at the major industrial areas of the Burrup, the North West Shelf, at Kalgoorlie and to a lesser extent at local industrial areas throughout the region. Emissions to air are regulated through the Department of Environment instruments and reported through the National Pollution Inventory (NPI). The NEPM Air Guidelines provides ambient emission levels for particulates and specific pollutants such as nitrogen dioxide, sulfur dioxide, ozone an carbon dioxide. Management of amenity aspects of point source emissions in local industrial areas (such as odour and overspray) can be improved through considered planning, cumulative emissions modelling and adeqaute research into local meterological conditions to ensure that industry is appropriately located in relation to other industries and to residential areas.

The priority locations for air quality management are the Pilbara port areas and the Kalgoorlie/ Goldfields industrial areas.

In 2004, the Department of Environment released the Pilbara Air Quality Study Summary Report. The study confirmed that total dust levels from a variety of sources often exceeded the Air NEPM guidelines. Furthermore, it was found that it was only at Port Hedland and Dampier that particulate matter (primarily dust, salt spray and occasionally bushfire smoke) exceeded the standards. The Department of Industry and Resources has undertaken a study of cumulative impacts for Port Hedland.

A Gap Emissions Study to identify the airborne emissions of significance in the Goldfields Area has been initiated by the Department of Environment. Stage one has identified that sulphur dioxide and particulates warrant further investigation. There are a number of government and industry dust monitoring stations around Kalgoorlie. In addition, there is a network of ambient sulphur dioxide monitoring stations. The *Environmental Protection (Goldfields Residential Area) Policy and Regulations 2003* set limits for ambient sulphur dioxide concentrations. These limits become progressively more stringent over time until they come into line with the Air NEPM standard.

Excluding the effects of land clearing, the emissions of greenhouse gasses from WA grew by 34 percent from 1990 to 2002. The biggest growth has been in the energy sector with a 43 percent increase and this sector is now taking action to increase efficiencies. Actions taken, particularly in the natural gas sector in the North West, include the use of combined cycle power generation and waste heat recovery plus the continuing investigations into the geosequestration of carbon dioxide produced as a natural gas by-product. This effort is necessary because of the precise requirements of natural vegetation, and the impacts that changes in food and habitat would have on natural communities. For example, nearly one third of the 58 species of eucalypt in the Kimberley are endemic to the region and have a preferred mean annual temperature range of 3^{o}C. A rise in temperature of more than that will result in changes in the biodiversity of the region.

2.6.14 Air RCTs and MATs

The following RCT and MATs for Air Quality have been suggested by the Department of Environment however, are yet to be fully prioritised.

RCT10: Air quality is within national standards throughout the Rangelands by 2020.

Management Action Targets		Geographic Focus	Actions	Potential Partner Groups	Links to RCTs	Priority
Benchmarking and Monitoring						
14 	Develop industry dust monitoring and reporting programs for all regional centres with industry by 2008	Major regional centres with industry	• Develop dust monitoring programs for Port Hedland, Burrup/Dampier and Kalgoorlie in partnership with industry and agencies. • Industry monitoring and reporting in accordance with Air Shed strategy direction, regulator requirements and industry best practice.	State Govt Industry Local Govt Community	RCT10	3
14 	NOx, SOx monitoring programs to be developed and implemented for the Burrup Peninsula and Kalgoorlie regional centre by 2008	Major regional centres with industry eg. Burrup and Kalgoorlie.	• Industry monitoring and reporting in accordance with Air Shed strategy direction, regulator requirements and industry best practice.	State Govt Industry Local Govt Community	RCT10	3
14 	Document the impacts of current fire management practices on air quality and biodiversity	Regional	• Extend Kimberley regional fire project. • Extend and adapt where necessary the existing fire management program into other sub regions • Guidelines developed for sugar cane burning • Link to NEMP	State Govt Local Govt Community	RCT10	3

On-ground Actions						
14 	Best management practice implemented for dust by 2008	Major regional centres	• Guidelines developed and implemented through regulator requirements and industry best practice. • Implementation of programs that also consider water use efficiency.	State Govt Industry Local Govt Community	RCT1 RCT10	3
14 	Best management practice for fire regimes and dust control implemented by 80% of land managers by 2015	Regional	• LCDC and pastoral industry BMP programs supported and reported. • Fire management included in property plans.	State Govt Local Govt Community	RCT1 RCT10	3
Institutional Frameworks, Planning and Policy						
14 	Industry adopts NEPM goals for particulates as a target by 2008.	Major regional centres with industry	• Implementation of dust management plans that also consider water use efficiency. • Strategies developed for places where achieving NEMP targets is unlikely	State Govt Industry Local Govt Community	RCT10	3
14 	Industry adopts best practicable emissions control technology for NOx and SO2 emissions by 2008	Major industrial areas	• Levels set in negotiation with regulator and industry best practice standards. • Implemented through environmental assessment and industry best practice standards.	State Govt Industry Local Govt Community	RCT10	3
14 	Strategic Air Shed policy and guidelines implemented for major industrial areas by 2010	Burrup Port Hedland Kalgoorlie	• Development of Strategic Air Shed policy and guidelines.	State Govt Industry Local Govt Community	RCT10	3
Cultural Heritage						
13a 	Culturally significant areas recognised in air shed planning by 2006	Major regional areas with industry.	• Investigation into potential impact of emissions on artefacts.	State Govt Industry Local Govt Community	RCT10	2

2.7 Waterscapes

2.7.1 Introduction

The Rangelands experiences the extremes of Western Australia's climate, from the monsoonal north, through the central arid zone, down to a Mediterranean-type southern climate (Figure 12). This climatic diversity influences an equally broad range of water resource assets.

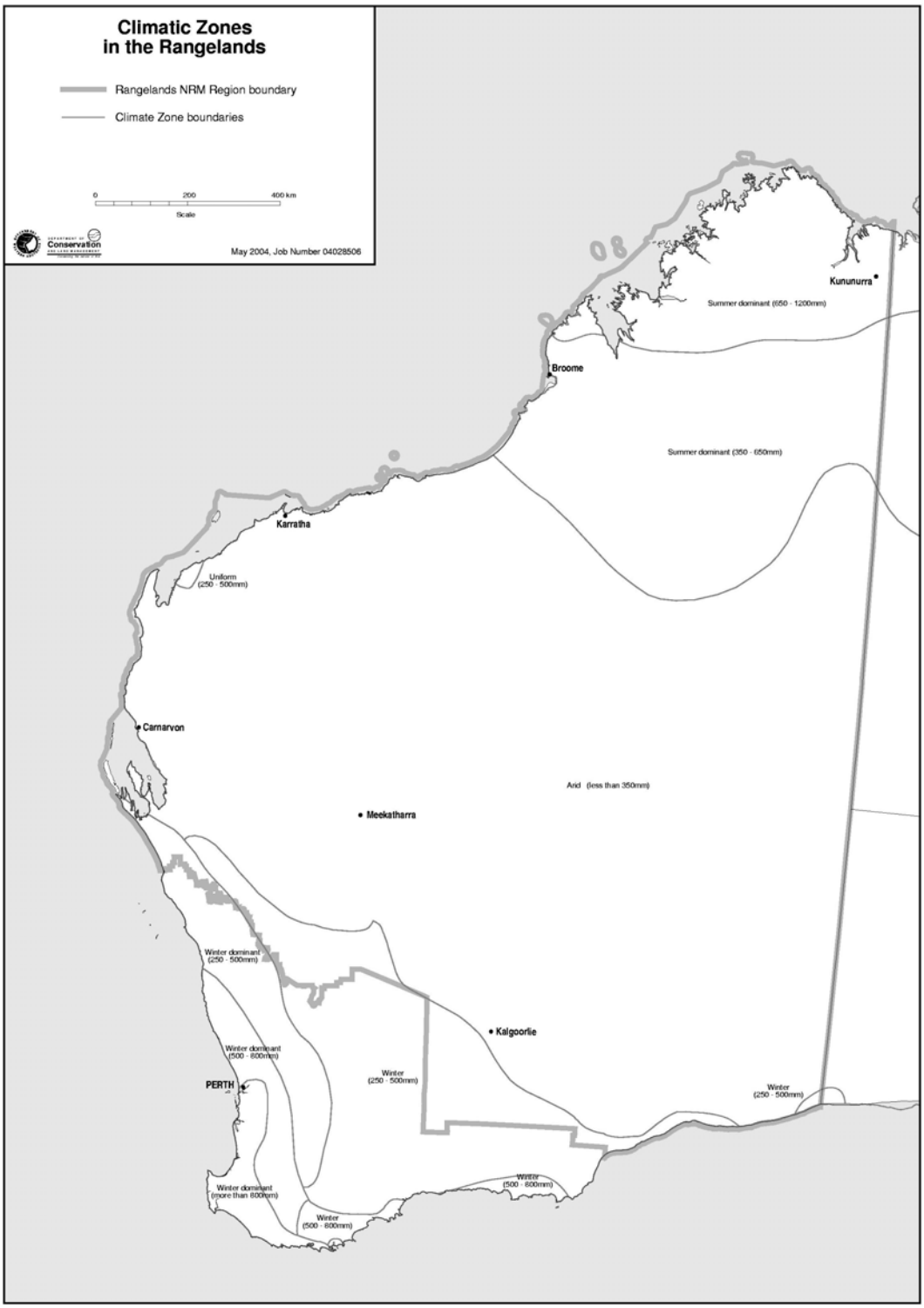


Figure 12: Rangelands' Climatic Zones

The nature of rivers varies with climate and drainage divisions from dry tropical in the Timor Sea Division, through episodic in the Indian Ocean Division, to largely ephemeral in the Western Plateau Division. A surprising diversity of wetlands occurs including spring-fed permanent pools, water table windows, mound springs, and marine interfaces. Groundwater resources vary from fresh to hypersaline and occur in fractured rock, river alluvials and sedimentary basins. Figure 13 below highlights the major surface water features of the region.

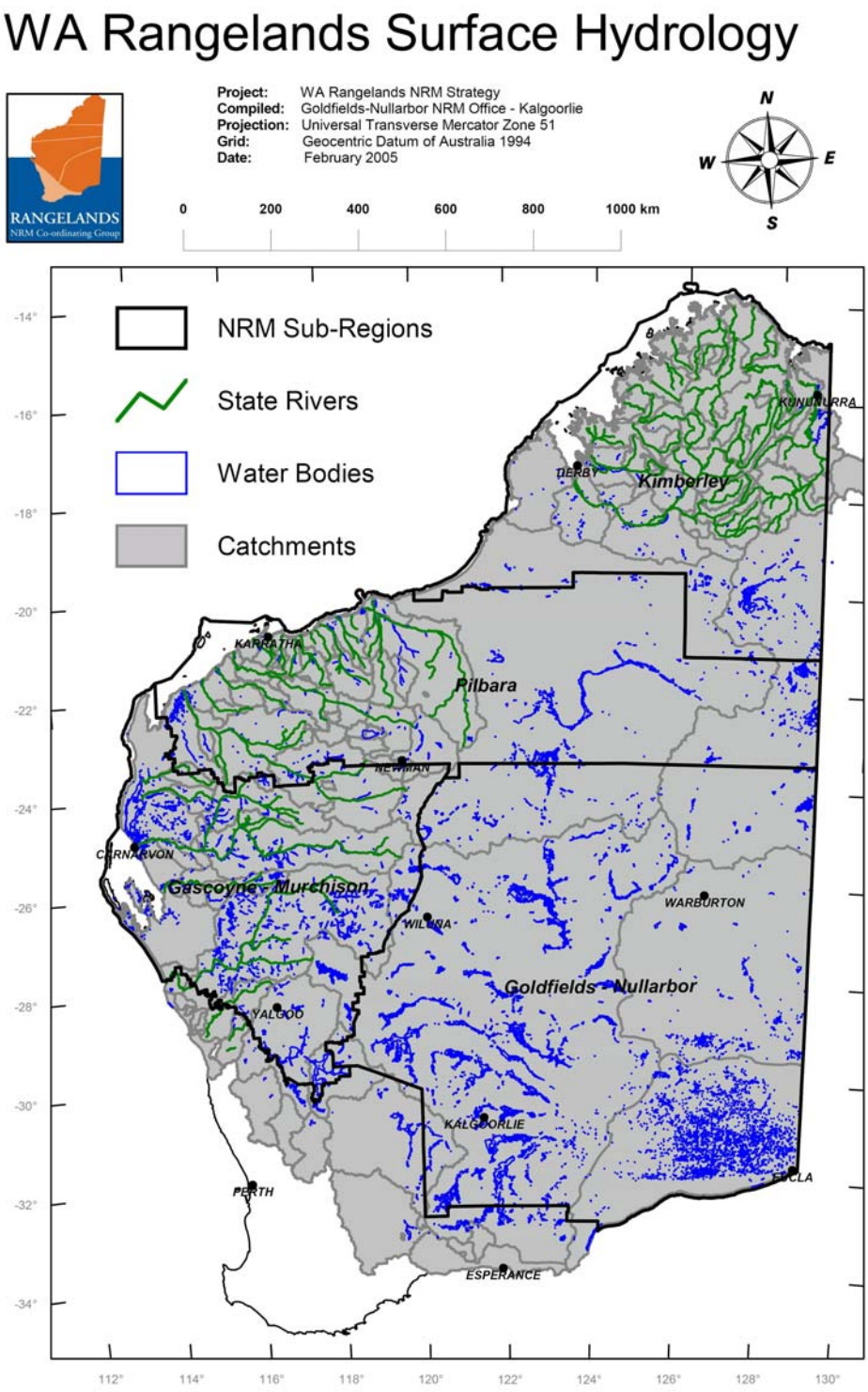


Figure 13: Rangelands' Surface Hydrology

Statewide assessments have provided guidance on prioritising the Rangelands' water resources. The three reports used primarily for this purpose are the *Statewide Waterways Needs Assessment* (2002), the *Preliminary Agency Statement of Natural Resource Management Priorities in Western Australia* (2003), and the *Western Australia Water Assessment* (2000). In addition, a preliminary discussion of the Region's rivers can be found in *The State of the Northern Rivers* (1997).

For the purposes of the Rangelands NRM Strategy, the sub-regional waterscape assets are outlined for the water resources of:

- **Waterways** – general term for any stream, river, lagoon or water course, either flowing or dry;
- **Wetlands** – areas of seasonal, intermittent or permanent waterlogged soils or inundated land eg lake, swamp, damp land; and
- **Groundwater** – water stored underground in the pores and crevices of rock or soil.

This section highlights the major values and uses of waterscape assets and provides an overview of the major threats to them. Current management and future management direction are discussed to address these threats. It also provides an overview of the aquatic biodiversity assets associated with Rangelands waterscapes.

Appendix I also provides more detailed information about major uses and values, and threats of natural resource assets in the sub-regions.

The RCTs and MATs for this section are divided into "water quality", "water regimes" and "aquatic biodiversity" reflecting the ways in which waterways, wetlands and groundwater assets are best managed and protected.

2.7.2 Waterways

Kimberley

The Kimberley has some spectacular and significant waterways. It is home to more than 100 rivers and many more creeks and streams, flowing northward or westward, out from the Timor Sea drainage division. They exhibit highly seasonal flow conditions as a result of being located at the southern edge of the global monsoon system, where intense and widespread rainfall results in flood flows during summer.

The largest river in the Kimberley, and in fact in Western Australia, is the Fitzroy, which has a floodplain that often spans over 40 kilometres and has significant ecological and cultural values. There is currently strong interest in the Fitzroy River particularly as a potential future Perth water supply source.

The second largest river in the Kimberley is the Ord. Two dams have modified the Ord River. Whilst this has reduced the floodplain inundation the permanent water and constant flow have resulted in some new ecological values.

The different land types within the Kimberley's catchments underlie their robustness. The sandy plains and river banks in the east and west Kimberley catchments are generally more susceptible to catchment deterioration and soil erosion from the impacts of fire, grazing animals and flooding, but the rocky catchments of the North Kimberley are not as prone to these pressures. Many of the Kimberley's rivers such as the Ord are naturally turbid due to natural flow regimes and tidal influences.

Waterways in much of the Kimberley remain largely unmodified. Rivers with catchments in near to natural state have been classified by the Australian Government Department of Environment and Heritage as "Wild Rivers" and there are 33 of these in the Kimberley. For a detailed list of the region's "Wild Rivers" see Appendix VIII, Attachment One.

AusRivAS monitoring of Kimberley's rivers between 1994 and 1999 found 37 of 50 sites close to natural state. The results indicate that the sub-region's rivers are in good condition, although more research is

needed to validate these results. Currently no widespread program of monitoring river condition exists and therefore knowledge of systems, and any changes or impacts from land use is limited.

Pilbara

Rivers in the Pilbara are subject to huge variations in flow. The five drainage basins in the Pilbara – the Ashburton, Fortescue, De Grey, Onslow Coast and Port Hedland Coast – fall within the Indian Ocean drainage division. The main drainage features include the Hamersley and Chichester Ranges, from where many streams arise. All but the larger rivers disperse in coastal flats before reaching the ocean and flow is heavily dependent upon rainfall from cyclonic activity when floods bring much needed rejuvenation. However, floods also cause severe damage to floodways, roads and pastoral land. Whilst flooding does occur, periods of three years or more without flow are common.

The Indian Ocean division is predisposed to soil erosion because of its often fine textured soils and the highly intense rainfall it experiences. However, the spinifex covered hard rocky soils of the Hamersley and Chichester Ranges in the Pilbara are more robust.

Because of the episodic nature of rainfall, there is a strong correlation between rainfall, water quality and river condition. Natural characteristics such as flood and fire generally have a strong influence over river condition and other impacts such as the introduction of weeds, and pressure from domestic and non-domestic animals are superimposed on these.

Many of the Pilbara's rivers feature spectacular gorges and permanent pools which are highly valued cultural, recreational and tourism locations. Rivers in an arid environment are ecologically important with some harbouring rare endemic species of aquatic flora and fauna. Four "Wild Rivers"and many significant desert rivers, such as the Rudall River, exist in the Pilbara. See Appendix VIII Attachment One.

Gascoyne-Murchison

The main catchments in the Gascoyne-Murchison are the Gascoyne, Murchison, Wooramel and Lyndon/ Minilya. All waterways in the sub-region are ephemeral and rivers dry up for at least part of the year. This lack of flow can extend for periods of more than twelve months, with the Gascoyne River for example, having a 60 percent probability of not flowing in any month.

The Gascoyne River basin has a total area of approximately 77,600 square kilometres, with the Gascoyne River originating from rangelands more than 780 kilometres inland. The River passes through pastoral land for most of its length, eventually discharging into the ocean at Carnarvon. Tributaries of the Gascoyne River include Lyons River, Turner Creek, Thomas River and Dalgety Brook. The majority of flow along the River occurs between February and August, although in some years the River does not flow at all.

The Murchison River basin covers more than 91,000 square kilometres and encompasses the tributaries of the Sanford, Roderick, Yalgar and Hope Rivers. The lower reaches of the Murchison River incise through Tumblagooda limestone creating a spectacular gorge that is vested as a National Park. Kalbarri, a major tourist destination, is situated at the mouth of the Murchison.

The Wooramel River Catchment covers approximately 40,500 square kilometres and the Wooramel River originates from sparsely vegetated Rangelands about 350 kilometres inland. It flows to the coast in a westerly direction through pastoral land for most of its length and discharges into Herald Loop in the Shark Bay Marine Park within the World Heritage listed area.

The Lyndon and Minilya Rivers are two relatively small rivers, originating from Rangelands approximately 200 kilometres inland and both discharge into Lake MacLeod, a wetland listed as being of National significance by the Australian Nature Conservation Agency (ANCA).

Goldfields-Nullarbor

The majority of the Goldfields-Nullarbor is located within the Western Plateau drainage division, which is the largest of Australia's surface hydrology divisions, covering 32 percent of the continent or 1,415,000 square kilometres (56 percent of Western Australia). It is typified by uncoordinated internal drainage and is almost completely devoid of major riverine landform features; although there are three listed "Wild Rivers" (see Appendix VIII, Attachment One).

None of the sub-region's watercourses drain into the ocean but rather disappear in flat areas or shallow lakes. Most waterways are short and all are ephemeral, flowing infrequently and only for short periods following large episodic rainfall events. During such events large areas are flooded as local basins fill and overflow, which is followed by an explosion of productivity by previously dormant organisms. Flood events have the added benefit of flushing accumulated organic matter (and associated nutrients) from permanent and semi-permanent pools and allowing the transfer of genetic material of aquatic organisms between pools or refuge sites.

2.7.3 Major Uses and Values of Waterways

Ecological Values

Waterways and their fringing vegetation support important ecological functions and values such as habitat, breeding areas, drought and threatened species refuges. They also mitigate floods, increase water quality and provide habitat for organisms.

During the dry periods, permanent river pools become vital refuges for aquatic invertebrates, water birds and other fauna.

Recreational and Aesthetic values

Rivers in the Rangelands are the focus of tourism, fishing, boating and other recreational activities. The majority of visiting and local campers choose to stay alongside rivers, for aesthetic reasons as well as for access to water for swimming, fishing, cooking and washing. Many of the Region's rivers feature spectacular gorges and permanent pools that are highly valued recreational and tourism attractions. Often highly valued recreational and aesthetic sites also have significant cultural and ecological values.

Cultural Values

Waterways hold special significance for Indigenous people. Many cultural beliefs and stories are focused on rivers, and rivers continue to provide food resources and enjoyment to these communities.

Over 40 percent of the Kimberley's population is Aboriginal, with many people either living on or accessing country regularly, including water sources. Likewise in the Pilbara there are significant cultural values associated with most permanent water sources, particularly the Fortescue River and permanent pools at Millstream. Waterways in the Goldfields-Nullarbor also hold significance for Aboriginal culture, with permanent and semi-permanent pools forming part of a network of vital water resources for Aboriginal groups. Consequently, these sites are considered culturally significant.

Throughout the Rangelands much of the information regarding the cultural significance of waterways is not well documented and in danger of being lost as elders in Aboriginal communities pass away. Often this information can assist with waterway management responsibilities, improve biodiversity knowledge and help manage tourism impacts through education and awareness.

Water Supply

Relative to other parts of Australia, only a small percentage of the Rangelands' rivers have been dammed or modified. The construction of two dams on the Ord River in the Kimberley in 1963 and 1972 created Lake Kununurra and Lake Argyle, which support the Ord River Irrigation Area, as well as hydro-electricity generation. The Arthur Creek Pilot Dam in the Dunham/ Ord River catchment is also a supply source for irrigation and aquaculture. Additionally, the Moochoolabra Dam in the east Kimberley was constructed in 1971 to provide a reliable, good quality water supply to the town of Wyndham.

The Fitzroy Barrage and Seventeen Mile Dam constructed at Camballin in the Fitzroy catchment in the 1960s provide water for irrigation. There is current interest in the Fitzroy River as a potential Perth water supply source and as a water source for irrigated agriculture because of its large flood flows.

There are two water supply dams in the Pilbara, the Harding Dam located on the Harding River and the Opthalmia Dam on the Fortescue River, used to recharge the town water supply borefield. Impounded water supplies experience high evaporation rates, turbidity caused by temperature changes and recharge is from infrequent and unpredictable rainfall or river flow.

The highly variable flows of the Gascoyne River play a significant role in recharging the groundwater resources of the Lower Gascoyne River, which support a major horticultural industry.

Some northern pastoral properties use rivers for stock water, fattening paddocks and transport routes, and rivers on some leases also define property boundaries. However, in other parts of the region (Gascoyne-Murchison and Goldfields-Nullarbor) stock water for pastoral operations is generally not sourced from rivers and is predominantly provided via bores. Throughout the Rangelands, windmills and solar pumps are used to supplement natural watering points.

2.7.4 Major Threats to Waterways

Waterways throughout the Rangelands are subject to a range of both human induced and natural threats. Natural conditions that provide stress to riverine systems include long dry periods, intense rains, flooding and fire. However, natural plant and animal communities are adapted to be able to cope and rebound from these stresses.

Human activities placing pressure on river condition include tourism, pastoralism, irrigation and mining, with potential impacts including erosion, pollutants, litter, and vegetation and biodiversity loss.

Impact of Animals

Concentrating animals in riparian areas for long periods impacts on riparian vegetation and riverbank stability, causes sedimentation and decreases water quality. However controlling access to riparian areas can sometimes prove difficult due to the cost of fencing particularly for large properties and the ongoing maintenance from the impacts of flood events.

One of the most serious causes of waterways degradation in the Kimberley is the removal of natural riverine and catchment vegetation, resulting in soil erosion and sedimentation. Overgrazing by domestic and non-domestic herbivores prior to the 1970s has destroyed some vegetation and exposed fragile soil to the impact of highly intense rainfall. This results in sheet and gully erosion washing soil into rivers, making them highly turbid when flowing. This soil is then deposited along riverbanks, in pools and across estuaries. However, in some parts of the Rangelands the impact of animals on riparian areas is not as great as that of fire, floods and drought.

Plant and Animal Pests

Plant and animal pests also present threats to Rangeland waterways. For example, the potential invasion of cane toads represents a significant threat to riverine ecosystem health in the Kimberley.

Furthermore, Noogoora Burr is widely distributed along the Fitzroy and Ord Rivers, and other riparian weeds including passion vine and leuceana are becoming more widespread. Pressures on the Pilbara's rivers include the impact of noxious weeds such as Mesquite and Parkinsonia, which are becoming more widespread along Pilbara's rivers affecting riparian biodiversity. In fact, one particular station in the Pilbara has the largest Mesquite infestation in the country. Parkinsonia, Mesquite and Tamarix are also emerging plant pests along the Gascoyne River.

Changing Flow Regimes

Unsustainable use of water by mining operations can threaten water assets. For example in the Pilbara, some mining companies use rivers and creek lines to discharge excess water obtained when dewatering a mine pit. This changes groundwater dependent ecosystems to ones that are dependent on surface water. The cumulative impacts of mine dewatering and discharge in the Pilbara can adversely impact on riverine and other biodiversity through changed flow patterns, increased susceptibility to weeds and by creating additional drinking sources for feral animals.

Infrastructure such as roads, bridges, culverts, railways, pipes, power lines and dams have a cumulative impact on river morphology by altering natural flow regimes. The impacts caused by infrastructure vary with the scale of changes to flow. Water regime changes resulting from catchment scale clearing and degradation influences infiltration and runoff, flood events and sedimentation.

Changed hydrology associated with water abstraction, obstructions (dams and barrages) and land clearing for irrigated agriculture can threaten the health of the riparian zone and interfere with fish migration.

Speculation about major diversions of water from the Kimberley's rivers for agricultural or metropolitan uses raises concerns for wider recognition of *in-situ* waterway values. For example greater understanding is needed to determine what impact the diversion of water would have on the Fitzroy's vast floodplain, fish populations, channel formation, on the productivity of the inshore water of King Sound (in particular the pearling industry) and on Aboriginal recreational and cultural values.

Unmanaged Access

The increasing cost of caravan parks, and the shortage of camping and caravan sites is placing additional pressure on alternative river camping spots, especially roadside travel stops. Recreation and tourism focus intensive activity on small locations, particularly river crossings and permanent river pools, and these pressures are common at many permanent and semi-permanent pools throughout the Region.

Increased use of four wheel drive vehicles and the establishment of drive trails have also opened up previously inaccessible, sensitive areas. Vehicle tracks too close to rivers cause bank erosion, soil compaction, damage to vegetation and altered water flow patterns. The remoteness of many of these places however, makes control mechanisms such as signage, toilets, rubbish collection and camp fee collection impractical.

Changing Fire Regimes

Changing fire regimes can significantly alter and degrade riparian and floodplain vegetation, increase catchment runoff and nutrient export and therefore present a threat to the condition of waterways. Impacts on waterways include reduced water quality due to increased turbidity, nutrients and organic loads, altered bed form due to erosion and sediment transport and establishment of weed and fire dominated species in the riparian zone.

2.7.5 Current Management of Waterways

Research and Investigations

Qualitative information on the Region's river history and health exists in many forms however, to date cultural and land manager knowledge has not been adequately captured. Scientific research on the Region's rivers is expanding, with more comprehensive research triggered by proposed developments such as the Ord and Fitzroy.

Localised studies, particularly from the mining industry, have been undertaken and cumulatively built up knowledge on biology, river history and the effects of altered flow regime. This information, if better co-ordinated and collated, can build on and compliment studies undertaken by agencies to improve overall baseline information and assist with NRM.

Many projects to address issues such as the aquatic and riparian weeds and to increase recognition of cultural values are underway throughout the Rangelands. Community based NHT projects such as the Fitzroy fish project has added significantly to the knowledge of the Fitzroy River. Cultural values along the Fortescue and Sherlock Rivers are being documented as part of a project called Ngurra: 2Rivers. More opportunities are required for local landholders, Indigenous communities, government agencies and scientists to work together to identify practical approaches to managing and monitoring the typically extensive and remote river systems.

The Tropical Savannas Cooperative Research Centre (CRC) is conducting a research project on riparian vegetation across northern Queensland, Northern Territory and northern Western Australia. The project aims to define riparian health, develop practical methods to assess riparian zones, generate better understanding of threatening processes and evaluate techniques to manage those threats. More detail can be found at http://savanna.ntu.edu.au/research/projects/savanna_riparian_he.html.

Planning and Regulation

Environmental effects from mining in the Rangelands are generally intensely managed. The Pilbara Iron Ore Environmental Committee and the Department of Environment are working together to consider water management in the context of regional NRM outcomes.

The Department of Environment licences all surface water diversions in proclaimed catchments under the *Rights in Water and Irrigation Act 1914*. Rivers in un-proclaimed catchments (except the Ord and Fitzroy – these are in proclaimed catchments) are not managed for water diversion and are therefore potentially at risk from mining or other water-dependent developments.

Where it is appropriate, regulatory instruments and landuse planning advice are used to support improved waterway management outcomes. Agencies such as Main Roads are increasingly considering beneficial environmental outcomes into infrastructure projects.

Waterway protection and foreshore management plans such as the Lower Gascoyne River Action Plan and the Ord Land and Water Management Plan help guide management of issues associated with development, conservation and restoration of rivers and adjacent land.

Continuing to acknowledge cultural values and stories associated with the Rangelands' waterways will contribute to the overall level of knowledge to support management.

Weed Management

There are a number of initiatives throughout the Rangelands to control weeds in riparian areas. For example, the Pilbara Rivercare Officer and Department of Environment have been working closely with CALM, the Conservation Volunteers Australia and the Ngurawaana Aboriginal Community to control the spread of Parkinsonia along the Fortescue River. The Pilbara Mesquite Management Committee has

also been actively researching methods and undertaking on-ground work to control the spread of Mesquite along the lower Fortescue River – the largest infestation of mesquite in the Pilbara. Also along the Fortescue River, a management program exists to minimise the spread of the exotic date palm in the Millstream National Park. Similar initiatives to map and control Mesquite and Parkinsonia have begun in the Gascoyne-Murchison and along the De Grey River in the Pilbara.

A program to address the spread of Noogoora Burr in the Northern Rangelands was introduced to target the occurrence of the weeds along many camping areas around the Fitzroy River system. The project included consultation with pastoralists and Indigenous communities surrounding the river, mapping and eradication of weed infestations and also education of tourists and other river users. Both the Fitzroy and Ord Valleys are quarantined for recreational use, but there are fears it could spread upstream into other catchments by stray cattle, tourists, fishermen and river users.

Monitoring

Flow information from gauging stations is important for shaping sustainable development proposals, planning for infrastructure and water availability, and in some cases, to manage environmental flow requirements to protect ecological values and functions. Data has been collected as far back as the 1950s to assist development of flood management plans and flood mitigation projects, which protect susceptible towns.

Gauging station networks are established in the Kimberley, Pilbara and Gascoyne-Murchison however in some areas, gauging infrastructure and operation is decreasing. Gauging stations can log important information such as flow duration, frequency and stage levels, and also monitor various parameters such as salinity, pH and water temperature.

Although most rivers in the region are ephemeral, they are subject to summer cyclonic conditions that contribute to major flooding events, which can threaten waterways and adjacent infrastructure. For example, in the Gascoyne-Murchison, heavy rainfall from tropical depressions can cause severe flooding, particularly in the lower reaches of the Gascoyne River catchment. A levee was constructed in the 1960s around the southern side of the Gascoyne River to protect the town of Carnarvon from inundation, and an on-going flood mitigation program is being undertaken to alleviate the threat of further flooding to the town.

Industry monitoring to meet regulatory commitments has the potential to contribute to monitoring and evaluation requirements for natural resource management. River foreshore assessment surveys contribute to riparian condition monitoring and assessing the effectiveness of management responses.

2.7.6 Wetlands

Kimberley

Kimberley wetlands are unique ecosystems with significant cultural, aesthetic and conservation values. With rainfall in the Kimberley restricted to four to six months of the year, waterholes, river pools, springs, marshes and cave systems are vital to the existence of many mammals, birds, fish, reptiles, amphibians and invertebrates. The karst systems of the Kimberley contain subterranean wetlands and are part of interconnected surface and sub-surface wetlands systems.

The sub-region has four wetlands listed under the Ramsar Convention, 21 listed in the Department of Environment and Heritage's Directory for Important Wetlands (Appendix VIII, Attachment Two), and nine on the Register of National Estate.

Pilbara

Overall wetlands in the Pilbara are believed to be in generally good condition due to the local geology, remoteness and restricted access. Rivers or groundwater discharge derived from flood flows supports

the majority of the sub-region's wetlands and their longevity and health are predominantly influenced by the nature of the watercourses they rely on, and the periods between flooding. Generally speaking Pilbara wetlands are groundwater dependent.

Water quality naturally deteriorates as time since the last recharge event increases and algal blooms are common during extended periods of no flow. This can be exacerbated by increased animal use.

The Fortescue Marsh, Weeli Wolli Springs, Millstream and the Hamersley Range wetland systems are national and regionally important wetlands due to their cultural, social and ecological values. Many wetlands have invertebrate richness.

Gascoyne-Murchison

Although much of the Gascoyne-Murchison's surface water is ephemeral, there are a number of permanent pools and soaks that survive the hot summers as wetlands. These wetlands act as very efficient biological filters within river systems and catchments, are extremely important refuges for biodiversity, have high recreational values, and are considered significant both historically and culturally. The sub-region has a number of sites registered as wetlands of national significance, which are listed at Appendix VIII, Attachment Two.

The northern end of Lake MacLeod has also been proposed for listing as a wetland of international significance under the Ramsar agreement. Other wetlands in the Gascoyne-Murchison have generally not been formally identified, surveyed, classified and categorised. In many cases, land managers are aware of these and provide some form of management of them on their properties. Regionally significant wetlands include Lake MacLeod (potentially part of the proposed Ningaloo/ Cape Range World Heritage Area), Edithana Pool on the Lyons River, Rocky Pool and Fishy Pool on the Gascoyne River, and cave wetlands at Exmouth.

Goldfields-Nullarbor

Despite its predominantly arid climate, the Goldfields-Nullarbor contains a diverse assemblage of wetlands. These include large chains of intermittently inundated salt lakes along paleodrainage channels, permanent springs and rock pools (which are vital refuges for flora and fauna), semi-permanent to seasonally inundated meadows and microscale gnammas associated with granite outcrops, claypans, underground streams and pools and intermittently inundated freshwater lakes and soaks that formed part of a network of water sources supporting Aboriginal people.

Large areas of the sub-region's wetlands remain relatively pristine, particularly in its northern and eastern extremes. However, pressures from impacts such as grazing by domestic and non-domestic stock, unmanaged tourism and mineral exploration affect wetlands in the sub-region.

Seasonally or intermittently inundated salt and freshwater lakes, swamps and marshes provide important breeding sites for waterbirds and other fauna following large rain events. Some of the large intermittently inundated salt lakes, such as Lake Barlee, may only fill once every few years and once inundated, hold water for up to 12 months. These sites hold significant ecological value supporting large breeding populations of waterbirds including nomadic and migratory species. The subterranean wetlands of the Nullabor contain stygofauna species including amphipods and isopods and also have significant ecological value.

2.7.7 Major Uses and Values of Wetlands

Ecological Values

The Rangelands' wetlands containing semi-permanent or permanent water are important refuges for aquatic and terrestrial flora and fauna. Often these wetlands represent relatively rare and isolated

habitats within the region and therefore support similarly rare and unique assemblages of flora and fauna.

The ecological communities supported by wetlands are often unique combinations of plants and animals. Springs, marshes and floodplains support a diverse establishment of sedges and herbs that help to stabilise the sediment and provide habitat for animals. Reeds and grasses, and algae grow in or around these wetlands. Some invertebrates found in the springs include small crustaceans such as isopods, ostracods and snails, which are sometimes endemic to one group of springs.

Given the Region's arid environment, wetlands such as Eighty Mile Beach and Roebuck Bay are important water sources and refuges for water birds and migratory waders. Small sites such as springs, rock holes and small pans are also important.

The karst systems of the North West Cape Peninsular, Kimberley and Nullarbor contain subterranean wetlands and are part of interconnected surface and sub-surface wetland systems that have significant ecological values (subterranean aquatic fauna, or stygofauna).

Recreational and Aesthetic Values

Due to the rich ecological, social and cultural values that wetlands provide, an increasing number of tourists are visiting these places. Wetlands are valued as places for locals and visitors to go bird watching, exploring, or relaxing and enjoying the natural environment. Economically, wetlands contribute most to the tourism industry in the Kimberley, with lesser value for pastoral, mining and other industries.

Cultural Values

Wetlands are culturally significant areas through provision of food and water resources, and often are spiritual places of significance. Most wetlands in the Kimberley, for example, have stories associated with their formation and features.

Wetlands have provided Aboriginal people with a range of resources vital to survival. For example in the Goldfields-Nullarbor, knowledge of the types, location and approximate volume of wetlands was vital information passed on from generation to generation via oral histories and stylised maps (Bayly, 1999). The range of wetlands visited depended on rainfall with smaller temporary wetlands (eg claypans) visited following episodic rainfall events and used as a base for foraging. As these temporary sources dried up, groups would be forced to retreat to larger, more permanent sources. The wetlands visited may therefore vary from year to year depending on rainfall (Bayly, 1999).

2.7.8 Major Threats to Wetland Assets

Pressures or threats to wetlands vary according to a range of factors, including the geomorphology of the wetland and land use or tenure. In addition to natural factors causing poor water quality and algae outbreaks, stock and feral animals may foul water and can be significantly impact on them by trampling. Organic mound springs are particularly vulnerable to the impacts of trampling and to modification of spring flow from changing flow regimes. Wetlands are also subject to the natural pressures of high velocity flows from major flood events and consequent changes to site characteristics.

The Millstream Wetland System, listed in the Department of Environment and Heritage's Directory of Important Wetlands (Appendix VIII, Attachment Two) and arguably the most important system in the Pilbara, is also the primary source of groundwater abstraction for town water supply and industrial use. The health and status of groundwater dependent vegetation is the subject of on-going monitoring. Some years ago the system began showing erosion effects, possibly caused by a complex interaction of natural and human induced factors.

The current advance of the cane toad across the Northern Territory, estimates their arrival into the Kimberley late this year or ealy next year. Given the high ecological and cultural significance of the Kimberley's wetlands, the spread of cane toads is a significant NRM issue. Their arrival in the Kimberley threatens both land and aquatic biodiversity assets including biodiversity hotspots such as wetlands. Cane toad poison will also impact on animals that try to eat them, including freshwater turtles, goannas, fish, snakes and freshwater crocodiles. They also compete with native species for food, deplete beneficial insect populations and can pollute water holes.

2.7.9 Current Management of Wetlands

Management Tools

Current management of wetlands in the Rangelands is determined by a combination of land tenure and largely by the risk of direct impacts. Many of the registered wetlands are located on CALM Estate and are therefore managed for conservation values. However, the potential impacts of tourism and recreational use on off-reserve wetlands can only be managed through increased awareness and respect for wetland values. Information about the cultural significance of wetlands helps to build respect and awareness and is beginning to be practically applied to support protection and management.

Where mining and other major development activities may impact wetlands, they are protected through regulatory tools. NHT funding is often sought to assist landowners manage the impacts of stock on wetlands.

A significant issue identified in the Region is the need for an inventory of wetlands that can be assessed and categorised, establishing priority areas of action. Information on the values of the Region's wetlands is also limited in comparison with other parts of Western Australia where systematic inventories of wetlands have been conducted. As with rivers, this is in part a reflection of its remoteness and low population. A current project funded by WWF and NHT aims to establish priorities for wetlands conservation and management in the Kimberley.

Research and Investigations

Mapping of wetlands is limited by the extensiveness of the Region with most studies carried out on areas under pressure or proposed for development. Currently management decisions are guided by first principles. However, more formal identification of wetlands that are regionally significant and an increased understanding of the pressures impacting on them will support land managers in addressing these pressures.

The most comprehensive understanding of the condition of the Kimberley's wetlands is by Traditional Owners however, in most cases this has not been documented. An example of a current research and management project is the 'Managing Paruku IPA with Indigenous Knowledge'. Parku (Lake Gregory) is the most important arid zone wetland for waders in Australia and also holds significant contemporary cultural values for Aboriginal owners and managers. The project aims to build recognition of traditional and cultural outcomes at Paruku IPA. Partners include Kimberley Land Council, Kimberley Language Resource Centre, WWF and Department of Infrastructure, Planning and Environment.

Waterbird abundance and diversity has been documented at major wetlands such as the Fortescue Marsh, Mandora Salt Marsh and Lake MacLeod and there has been some very limited invertebrate work. Some wetlands of the Ord system, Roebuck Area and Mandoora Salt Marsh have had studies undertaken to consider ecological, social, cultural and economic values.

Additionally the Pilbara Biological Survey and the State Wetlands Data Project administered by CALM are contributing to an inventory of wetlands and improved understanding. Many of the less accessible wetlands in the Region however, are not documented.

Monitoring

Where wetlands have the potential to be impacted by proposed developments monitoring and investigation is required to manage potential impacts.

Monitoring of aquatic biodiversity is a core component of the Pilbara Biological Survey. Furthermore, monitoring undertaken by industry to meet regulatory commitments can also contribute to monitoring. Similar to waterways monitoring, an opportunity exists to better align monitoring techniques and capture information so that it can help contribute to NRM monitoring and evaluation techniques and requirements.

The Ribbons of Blue program (funded by NHT and co-ordinated by the Department of Environment) asseses wetland health through monitoring aquatic macro-invertebrates and water quality parameters. It also encourages the community to be more involved and proactive in waterways health.

2.7.10 Groundwater

Kimberley

The majority of the east and north Kimberley's hydrogeology is fractured rock, with a small sedimentary area north of Kununurra. The Dampier Peninsula and the area around Broome, and south of Fitzroy Crossing are all part of the sedimentary storage of the Canning Basin. Improved understanding of groundwater yields is often triggered by development proposals.

The Canning-Kimberley Groundwater Area covers the entire Kimberley sub-region. It was proclaimed in 1997 under the *Rights in Water and Irrigation Act 1914* to ensure groundwater is abstracted sustainably. Broome and Derby also have proclaimed Groundwater Areas.

Pilbara

The main aquifer types in the Pilbara are calcrete (Millstream), alluvial, fractured rock and sedimentary basin aquifers. Groundwater is abstracted from the Millstream aquifer to provide water supply for the West Pilbara and from the Yule and De Grey alluvial aquifers to provide water for the town of Port Hedland.

The Pilbara Groundwater Area covers the majority of the sub-region and is proclaimed under the *Rights in Water and Irrigation Act 1914*. The Pilbara Groundwater Area broadly consists of hard fractured rock as compared to the adjoining Canning Groundwater Division, which is described as a sedimentary rock basin. Investigations to support the development of new, or expansion of existing iron ore mines, have improved understanding of groundwater yields.

Gascoyne-Murchison

Throughout the Gascoyne-Murchison, groundwater is a very important resource. The Carnarvon Basin, a major physiographic area of subsurface storage, comprising Exmouth Gulf, Lyndon/ Minilya catchment, Gascoyne, Wooramel systems and Shark Bay is overlaid by unconfined, relatively young sedimentary silts and sands, with much older consolidated sandstones underlying, such as the Birdrong formation, which is a confined aquifer.

The Birdrong Sandstone system extends over an area of about 50,000 square kilometres and forms the most extensive aquifer in the sub-region. The geomorphology is comprised more of fractured rocks moving further inland.

All groundwater abstraction is managed under the *Rights in Water and Irrigation Act 1914*.

Goldfields-Nullarbor

The Goldfields-Nullarbor contains groundwater in fractured rock, paleochannel, unconfined alluvial, calcrete and sedimentary basin aquifers. Groundwater storage in fractured rock aquifers is significant with yields of up to 25,000 kilolitres per day obtained from localised sources. Significant quantities of fresh to brackish water are also stored within paleochannel aquifers, which are the main aquifer systems of the sub-region.

There are two sedimentary basin aquifers that, at least partially, occur within the Goldfields-Nullarbor – the Officer Basin and the Eucla Basin, both of which are located in remote areas and there is limited information on their characteristics.

Since the 1990s demand for groundwater in the northern Goldfields increased with development of two nickel operations, which are the largest individual consumers of groundwater in the sub-region. Most of the groundwater is extracted from paleochannel sand aquifers (Johnson *et al.*, 1999).

2.7.11 Major Uses and Values of Groundwater

Ecological Values

The environmental values of groundwater are not always as obvious as those of surface water assets. However, groundwater directly or indirectly supports a number of environmental values including stygofauna (in aquifer ecosystems) and troglofauna assemblages, groundwater dependent vegetation, maintaining base flows or pools in waterways and maintaining open water or waterlogged soils in wetlands.

Given the Regions arid environment many wetlands and vegetation communities are fully or partly reliant on groundwater for their survival. Some of these groundwater dependent ecosystems include world renowned sites such as the Ramsar listed Mandora Salt Marsh, although there are many more that are known, but for which traditional or scientific knowledge has not been documented.

Groundwater aquifers also support many endemic stygofauna communities, with information on stygofauna abundance primarily gathered in areas where there are development pressures. In the Pilbara, the Fortescue System, particularly the Millstream Aquifer, has many identified global stygofauna “hot spots”.

The calcrete aquifers of the Pilbara and north-east Goldfields and paleodrainage channels of the inland deserts are also significant aquatic environments. All of these are sources of subterranean aquatic fauna, or stygofauna. Stygofauna are likely to be involved in important ecosystem services such as maintenance of groundwater quality (EPA, 2003). The caverns and voids of the foothills of Cape Range and the coastal plains of the North West Cape Peninsular contain fresh to saline water. The blind gudgeon (*Milyeringa veritas*) and the blind cave eel (*Ophisternon candidum*) are the only vertebrate animals known from Australasia that are restricted to either caves or groundwater and are declared as threatened fauna under the *Wildlife Conservation Act 1950* (Morton et al 2005).

Cultural Values

In addition to maintaining many culturally significant wetlands, groundwater also has significant cultural significance. For example in the La Grange Groundwater Area south of Broome, the Traditional Owners refer to permanent groundwater sources, which sometimes have surface water present, as *jila*. Mythical water snakes (*pulany)* inhabit *jila* and other permanent water sources. Every *Jila* has its own songs, stories and skin groups. As such these permanent groundwater sources are culturally significant spiritual places, with which individuals have close, personal relationships.

In arid regions, people retreat from the less permanent water sources to the larger water sources maintained by groundwater in the hot, dry times.

Water Supply

Sustainable groundwater abstraction is important as many aquifers support permanent wetlands, which are important refuges during drought and or no flow periods. Almost all of the Region's domestic water supplies come from groundwater. Irrigated agriculture developments near Broome, Derby and Kununurra and in the Lower Gascoyne also rely on groundwater. Mining relies on groundwater for processing and often dewaters local aquifers to allow mining below the water table to occur.

The potential of the groundwater resource in the Kimberley has not been fully scoped. The fractured rock areas are unlikely to be able to support high yields for large-scale industry or irrigation. The sedimentary basin aquifer may have future potential for uses such as expanded irrigation or aquaculture. However, information on the risks associated with abstraction to endemic species and groundwater systems is unavailable. Consequently, there is uncertainty about how much groundwater can be allocated away from the environment for other uses.

The Pilbara is one of the most significant growth areas in the country and consequently management of groundwater for industrial expansion and town water supply is a priority NRM issue in the Pilbara. Mining operations in particular abstract groundwater for mine dewatering, dust suppression, mineral processing and ore beneficiation. Without a strong focus on water use efficiency, groundwater availability may become a major constraining factor on large-scale industrial expansion in the Pilbara, and ecologically sound development of the sub-region's water resources requires co-ordinated planning and investigation.

The Gascoyne-Murchison has a total dependence on groundwater for town water supplies and industrial developments, making its on-going assessment and management critical for the viability of Gascoyne-Murchison communities. This is particularly relevant in towns undergoing expansion, such as Exmouth. In smaller towns such as Denham and Coral Bay, there is a high cost for water provision due to the desalination processes that have to be undertaken to provide potable water. Additionally most towns, tourist centres, industry and agriculture in the Gascoyne-Murchison rely on groundwater as the only reliable water supply and it is also used for irrigation in the lower Gascoyne horticultural region. Investigations into potential new areas for horticultural expansion are currently underway, which has the potential to provide further valuable information on the distribution of the sub-region's groundwater resources.

In the Goldfields-Nullarbor, the saline paleochannel aquifer is used for mineral processing. The abundant supply of this resource is vital to the economic viability of many gold and nickel mining operations. A number of towns in the northern Goldfields do not have access to the Goldfields and Agricultural Water Supply scheme pipeline and are therefore reliant upon groundwater for their town water supplies. Town water supplies are obtained predominantly from fractured rock and clacrete aquifers.

Pastoralists have used free flowing bores in the Canning Basin opportunistically for many years. Although essential for economic viability, there are some environmental concerns with this form of use. However, rehabilitation and establishment of new watering systems is costly. The Department of Environment, Shire of East Pilbara, De Grey LCDC and the Rangelands NRM Co-ordinating Group are working in collaboration to secure funding to address this issue.

2.7.12 Major Threats to Groundwater Resources

Over-abstraction

Throughout the Rangelands many culturally and environmentally important wetlands, river pools, cave systems and ecosystems are maintained by groundwater. Over-abstraction of groundwater or changes to flow patterns or water quality can threaten the integrity of the ecosystems they support. For example, in the Pilbara, local aquifers supplying water to towns and port operations also support significant wetland systems and stygofauna populations. The demands of a rapidly expanding mining industry

highlight the need for careful planning and management of water sources. Inefficient water use practices by industries and communities, and increasing pressure for better dust management to meet community expectations, adds to demand pressures.

In the Gascoyne-Murchison, abstraction of groundwater is carefully managed to minimise impacts on cave systems such as Cape Range. The groundwater of Cape Range in the Gascoyne-Muchison is a very important part of a karst environment supporting a suite of subterranean fauna of significant conservation value. The town of Exmouth and the surrounding infrastructure also draw water from the same groundwater source, thus necessitating a high degree of management. Carefully managed abstraction of water in the Carnarvon irrigation district also occurs to minimise potential groundwater quality impacts such as salt-water intrusion.

Little information exists on the groundwater requirements of ecologically and culturally significant organic mound springs and cave systems, such as those that occur throughout the Kimberley and Gascoyne-Murchison. Often the aquifers supporting these ecosystems are also potential sources for large-scale horticultural and agriculture developments and town water supplies. Increase in water use as a result of pastoral diversification, particularly in the Kimberley, requires sustainable water use planning.

Over-abstraction can also occur through allowing artesian bores to flow uncontrolled. In addition to the environmental problems this can cause, it is an inefficient use of groundwater resources and may have long-term impacts on the ability of the aquifer to supply a reliable source of water.

Disruptions to groundwater regimes through abstraction can have large impacts on calcrete aquifer karst systems. The watertable of North-west Cape Peninsula may be declining and becoming more saline (Morton *et al* 2005). Total catchment management processes are therefore important to minimise impacts. Threats to the Nullarbor systems and the subterranean wetlands of the Kimberley include altered hydrology and water quality.

Contamination

The combination of high rainfall and sedimentary basins, particularly in the Kimberley, requires careful management of pesticides and fertiliser use to prevent contamination of groundwater systems.

The use of groundwater for mining operations may threaten water quality and groundwater dependent ecosystems. Dewatering may have localised impacts on wetlands and terrestrial ecosystems that rely on groundwater for survival and stygofauna populations. Mine voids may change local groundwater regimes and there is potential for mine void pits to become point sources of hypersaline water and contaminate local groundwater sources. Where tailings are disposed back into mine voids, leaching also can contaminate groundwater.

Inappropriate land uses can impact on quality of groundwater, particularly drinking water supplies. Recognition of water source protection areas in local planning strategies will control incompatible land uses. Local Aboriginal communities and private domestic users may benefit from guidance and support to manage potential threats to private drinking water sources. Lack of appropriate facilities and management at popular tourism locations may also cause local water quality problems.

Groundwater contamination can have a significant impact on karst communities. Threats to the North West Cape karst system includes unplanned road building within the area, which may alter water levels and quality by causing sediments and nutrients to leak into caves. The fauna is also potentially threatened by development of Exmouth as a residential and tourist centre by contamination of groundwater and surrounding waters by excessive nutrients, heavy metals and/ or hydrocarbons.

In the Kimberely, stock access to karst springs may potentially contanimante subterranean wetlands.

2.7.13 Current Management of Groundwater

Research and Investigations

Research and investigation is mostly undertaken in areas under pressure or proposed for development. Some preliminary studies have been undertaken in the East Kimberley (Ord River Irrigation Area and Argyle mine site) looking at the stygofauna, in an attempt to understand the biodiversity of these ecosystems.

Several ecological and cultural investigations have been undertaken throughout the region in response to proposed developments. The *Ngapa Kunangkul: Living Water* report captures the Aboriginal cultural values of the groundwater in the La Grange sub basin. Similar studies have been undertaken along the Fitzroy River and in the Pilbara.

The Pilbara Biological Survey has looked at stygofauna diversity throughout the Pilbara. Other studies are looking into the diversity and endemicity of stygofauna in the Goldfields-Nullabor.

Planning and Regulation

Under the *Rights in Water and Irrigation Act 1914*, the right to use, flow and control groundwater is vested with the Crown, and the Act requires licensing of all confined wells in Western Australia. Unconfined wells that fall within specific areas proclaimed as Groundwater Areas also require licensing. Potential impacts to groundwater dependent ecosystems through water abstraction are minimised through regulatory instruments and demand management. Impacts of mine pit dewatering and discharge are the focus of new management initiatives to minimise cumulative environmental impacts.

Groundwater Allocation Plans have been developed to achieve a sustainable use of groundwater resources in sensitive and heavily utilised areas to ensure groundwater resources remain at sustainable levels for industrial, public water and environmental requirements. Important cultural and social values are protected through the development and managing of environmental water provisions.

Contamination of groundwater drinking supplies is managed under the *Country Areas Water Supply Act 1947* and through Drinking Water Source Protection Plans. Opportunities exist to improve implementation of water source protection measures for privately operated schemes.

Planning for future water supplies through studies such as the Central Pilbara Groundwater Study provide a review of the groundwater resources and assess the possible impacts from increasing water use. In the Gascoyne-Murchison, the Lower Gascoyne Management Strategy (LGMS) was developed to address water allocation and abstraction issues associated with developing the irrigated horticulture area at Carnarvon.

Consideration needs to be given to the Ramsar category of “subterranean wetlands”. None of those found in Western Australia are currently Ramsar listed although others are within Australia. Many within the Rangelands are likely to qualify as significant subterranean wetlands, which will increase their profile and recognition of their importance by the community.

On-ground Management

A notable groundwater management project in the Rangelands is the Carnarvon Artesian Basin Rehabilitation Project, which is an on-going initiative. Implementation of water management plans, decommissioning open flowing bores, and installation of reticulation to direct water to strategic locations has resulted in significant water savings (estimated to be 50 gigalitres per year). A similar project has seen National Landcare Program funding obtained to cap artesian bores in the Canning Basin.

Significant economic and environmental benefits of both projects include improved management of total grazing pressure through better distribution of water to domestic animals and greater control of non-

domestic species, more efficient and sustainable use of natural resources through better distribution of water and increased access to water for other land uses such as tourism, aquaculture and horticulture.

The Canning Basin program complements other rehabilitation initiatives, like the Carnarvon Artesian Basin Rehabilitation Project and has similar environmental and production issues.

2.7.14 Water Quality RCTs and MATs

RCT11: By 2025, water quality in priority areas to meet targets or standards to be established in 2006

Management Action Targets		Geographic Focus	Actions	Potential Partner Groups	Links to RCTs	Priority
Benchmarking and Monitoring						
5 	**W1.** By 2008, the region's water values and associated threatening processes have been identified, characterised and prioritised for the Rangelands	Regional	• Review existing qualitative and quantitative water data • Identify priority areas • Recommend future management actions • Identify human communities partially or fully dependent on groundwater	State Industry Research Traditional Owners	RCT11	2B
5 	**W2.** By 2006 determine benchmark indicators and targets for water quality for priority locations	Priority Areas	• Identify baseline water quality datasets • Determine appropriate indicators for aquatic environments that account for natural variation • Determine thresholds for intervention • Establish management systems for water quality data and undertake additional investigations where required • Draw on and expand existing databases and State of the Environment Reporting where suitable	State Industry Research Community	RCT11	2B

Management Action Targets		Geographic Focus	Actions	Potential Partner Groups	Links to RCTs	Priority
On-ground Actions						
5 	**W3.** Protection plans developed and implemented for all public water supply areas by 2010,	Public Water Source Protection Areas Private water drinking supplies	• Review implementation of existing plans • Implement recommendations as per Protection Plan. • Encourage private users to develop and implement water source protection plans • Encourage compliance with licensing requirements for water use • Complete planning for existing water supply areas • Future water supply areas are identified and protection plans developed • Review statutory planning processes to ensure consideration is given to protecting the quality and quantity of future water supply areas • Review Town Planning Schemes to ensure the schemes protect water supply areas. • Guidelines and standards established to ensure proposed development does not impact on water quality • Future development proposals enhance water quality where previous landuse practices have impacted on natural variations. • Embed guidelines in local, regional and state planning processes • All planning processes in the Rangelands to include traditional owner consultation and/or continued involvement	State Local Government Community Industry Traditional Owners	RCT11 RCT1	2A
11 	**W4.** By 2008, 50% of private water users are implementing Best Practice Management Guidelines for protection of water quality for the Rangelands	Private water sources	• Develop BMP guidelines and support implementation for irrigation, pastoral, tourism & recreation, mining, fishing& aquaculture, private users and urban/townsite landuse. • Implement Best Practice Management Guidelines for protection of Water Quality in wetlands and waterways • Promote a total water cycle approach, including waste water use • Align programs with the National Water Quality and State Water Quality Management Strategies • Identify water quality monitoring parameters and priority areas • Implement water quality monitoring in priority areas targeting pH, salinity, nutrients, toxics and erosion • Use water quality monitoring data to make informed decisions on priority catchment management projects	State Local Gov Community Industry Traditional Owners	RCT11 RCT1	1A

Management Action Targets		Geographic Focus	Actions	Potential Partner Groups	Links to RCTs	Priority
Education, Awareness and Further Engagement						
11 	**W5.** By 2006, 4 waterways management education programs have been developed and implemented, which include water quality monitoring, riverine and wetland fauna and flora and groundwater management.	Regional	• Two Programs in Kimberley, One in Pilbara, one in Gascoyne-Murchison • Identify education needs for groups (community, schools, industry and agency) eg. Ribbons of Blue • Develop programs to meet needs of groups • Implement programs • Interpretational signage at priority aquatic ecosystems • Appoint an education co-ordinator • Support the implementation of the State Water Strategy • Water wise programs • Increase awareness and encourage uptake of technologies for water reuse • Culturally appropriate communication of ecosystem processes associated with rivers. • Raise awareness of the importance of wetland ecosystems and cultural importance • Expansion of freshwater sawfish community education and scientific research undertaken in the King Sound and Cambridge Gulf systems by 2006	Community Research State Gov Local Gov Industry Schools Tourism Pastoral Traditional Owners	RCT11 RCT1 RCT14 RCT15	1B
	See MAT L17					
Education, Awareness and Further Engagement						
	See MATs L18, L19 L21					

2.7.15 Water Regimes RCTs and MATs (includes water use)

RCT12: By 2025, water regimes sufficient for ecological function, as measured by indicators to be set by 2007, are maintained or improved in priority and/or high value conservation areas

RCT13: No reduction in the "Wild River" status of all Wild Rivers in the Rangelands from 2005

Management Action Targets		Geographic Focus	Actions	Potential Partner Groups	Links to RCTs	Priority
Benchmarking and Monitoring						
12 	**W6.** By 2007 all of the region's water supply sources have been identified and assessed for their capacity to meet demand projections	Regional Priority areas	• Identify and prioritise future water supply areas for further investigation • Develop demand scenarios for future use • Include drought contingency supplies and climate change	State Local Government Industry Community	RCT12 RCT13	1B
5 	**W7.** By 2007 develop benchmark baseline water monitoring programs and determine ecological water requirements for water resource assets where development pressures are greatest	Regional	• Identify areas where baseline environmental monitoring should be implemented and EWR surveys required. • Identify values and establish ecological water requirements for priority areas • Catchment hydrology monitoring networks established to capture baseline information • Use monitoring information for town planning, flood plain management, catchment management, infrastructure and development. • Information to feed into the development of EWRs/ EWPs	State Industry Research	RCT12 RCT14	2A

Management Action Targets		Geographic Focus	Actions	Potential Partner Groups	Links to RCTs	Priority
On-ground Actions						
11 	**W8.** By 2007 all major water users in the Rangelands to implement actions to achieve benchmark water use efficiency targets	Regional Priority Areas	• Water conservation management plans a requirement of licensing • Implement water use efficiency and water reuse programs in all towns • Benchmark water use efficiency targets set for all major water users • Work with WC to establish water use efficiency targets for scheme suppliers and customers • Work with industrial users to establish water use efficiency targets	State Industry Community Local Government Traditional Owners Lease holders	RCT12 RCT13 RCT1	1A
11 	**W9.** Cap 50% of free flowing bores by 2010	Gascoyne-Murchison Pilbara	• Implement in line with National Artesian Basin programs	State Local Government Industry Traditional Owners Community	RCT1 RCT12 RCT13	1A
4 	**W10.** By 2010, Best management practice implemented to minimise changes to water regimes and catchment hydrology from abstraction, discharge, clearing, and reduced infiltration by all mining, pastoral and irrigation sectors	Regional	• Utility activities to maintain ecological water requirements • Mining and irrigation activities to reduce discharge through improvements to water use efficiency • Pastoralist to improve infiltration through vegetation cover and soil condition management on catchment scale • Develop Best Practice Management Guidelines for protection of water regimes	State Industry Local Government	RCT1 RCT12 RCT13	2A

Management Action Targets		Geographic Focus	Actions	Potential Partner Groups	Links to RCTs	Priority
Institutional Frameworks, Planning and Policy						
4 	**W11.** Water Allocation and Management Plans developed for 10 priority surface and groundwater areas by 2010	Regional	• Prioritisation schedule developed for sub regions based on development and protection pressures • Develop water management plans including ecological water requirements. • Incorporate Aboriginal values and priorities for water resources • Where appropriate declare surface water area under the Rights in Water and Irrigation Act • Maintain effective water use through licensing of current and new water use by monitoring • Licensing process to guide optimal water use efficiency practices	State Local Government Industry Traditional Owners Community NGOs	RCT11 RCT12 RCT13 RCT14 RCT1	2A
4 	**W12.** Water sensitive urban design guidelines and water reuse systems adopted for 40% of communities and towns by 2010	Regional	• Water urban design guidelines applied • Treated effluent reuse guidelines applied • Increase grey water use in towns and communities	State Industry Community Local Government Traditional Owners	RCT11	2B
	W13. Develop and implement 2 floodplain management plans in priority areas by 2010	Priority areas	• Identify extent of priority floodplain areas and quality of riparian vegetation to set benchmarks by 2008 • Develop management plans to manage riparian vegetation in prioritised sensitive areas • Use the Rights in Water and Irrigation Act as a land use planning tool to minimise impact to flood plains and river crossings • Implement management plans based on set benchmarks and continue implementation of existing management plans for floodplains	State Local Government Industry Community Traditional Owners	RCT14 RCT15	3A
Education, Awareness and Further Engagement						
	See MAT L17					

Management Action Targets		Geographic Focus	Actions	Potential Partner Groups	Links to RCTs	Priority
Cultural Heritage						
11 	**W14.** By 2008 a process has been developed and is being implemented to identify cultural values related to waterways and ensure Indigenous involvement in waterways management	Regional	• Capacity building for Traditional Owners to document their history. • Develop projects to establish links between environmental and cultural values for more comprehensive management. • Identify culturally significant/sensitive sites to be protected. • Support traditional owner involvement in water supply management • Millstream Park Council participate in management of Millstream • Traditional Owner Councils participate in management of water sources • Implement mechanisms to facilitate traditional owner participation in managing impacts to waterways and wetlands • Improve shared knowledge and respect of Aboriginal values and waterways • Tourism opportunities developed in partnership with Traditional Owners • Mechanisms for better Aboriginal involvement in water supply management are developed and utilised • Aboriginal people are involved in making decisions about water resource management • Capacity building initiatives are in place to support traditional owner waterways management responsibilities on Aboriginal land	State Local Government Traditional Owners	RCT2 RCT12 RCT13 RCT1 RCT14	1A
	See MATs L18, L19 L21					

2.7.16 Aquatic Biodiversity Assets

Aquatic biodiversity, in the context of this Strategy, relates to organisms that either permanently or periodically inhabit areas associated with permanent or ephemeral freshwater, or naturally saline systems and riparian zones. Such areas include rivers, streams, creeks, lakes (permanent or ephemeral), swamps, claypans and underground water. These organisms include invertebrates (including aquatic stygofauna), fish, amphibians, reptiles (including crocodiles, turtles and some monitor species), waterbirds and waders, aquatic flora and algae, and riparian vegetation. Throughout the expanse of the Rangelands there is high aquatic biodiversity in a range of aquatic environments. Significant factors influencing the composition and life histories of aquatic biodiversity include climatic and geological variation thoughout the Region.

No systematic survey of aquatic biodiversity has been concluded in Western Australia to date, though there have been a number of aquatic surveys completed by CALM and the Department of Environment (see Figure 32). There is also no universally accepted approach for classifying waterways and wetlands in Western Australia.

In broadly outlining aspects of aquatic biodiversity in the Rangelands, some important features to note are:

- the diversity and endemism of fauna and flora of the large, seasonal rivers of the Kimberley, particularly freshwater fish species (eg. Barramundi, *Lates calcarifer*), Crocodiles (*Crocodylus* sp.) and freshwater marine species (Freshwater Sawfish, *Pristis microdon*, Northern River Shark, *Glyhpis* sp. C);
- the diversity of macro-invertebrate families in the Kimberley, Pilbara and Gascoyne (77 vs. 73 vs. 61) (Kay *et al*, 1999; S. Halse, *per. comm.*);
- the paucity of information on invertebrates in the Goldfield-Nullarbor, though recent work indicates a high level of endemism and high richness in the crustacean component (S. Halse, *per. comm.*);
- recent results for the Pilbara biological study that indicate very high species richness of aquatic invertebrates in comparison with wetlands of south-western Australia, with an average of 140 species at Pilbara sites to date compared to 60 species in southwest sites respectively (S. Halse, *per. comm.*);
- occurrence of aquatic stygofauna in Cape Range, North-east Goldfields, Nullarbor, Kimberley Karst Cave systems and cave systems in the arid interior;
- particularly important wetlands for waterbirds at Lake Gregory and Mandora Marsh in the south Kimberley, Fortescue Marsh in the Pilbara and Lake MacLeod in the Gascoyne (S. Halse, *per. comm.*);
- four Ramsar sites within the Kimberley (two of these are based in the coastal zone); and
- fifty seven wetlands of national importance occur within the Rangelands.

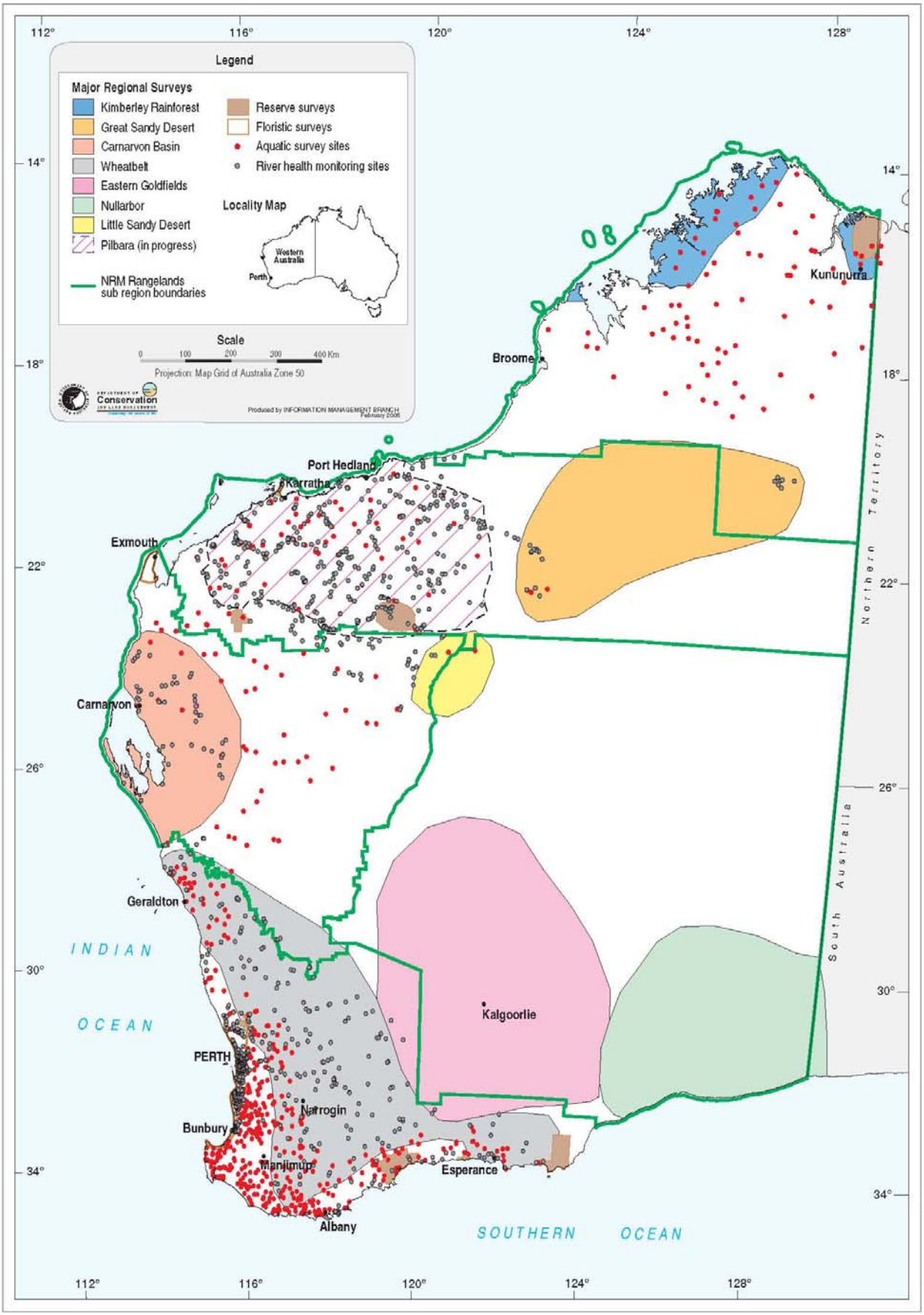


Figure 14: Major regional biological surveys, aquatic surveys and river health monitoring sites in Western Australia.

A number of aquatic organisms are listed on the State's threatened fauna list. Table 12 shows the number of species listed and the region in which they occur. The figure below represents a subset of the complete threatened fauna list which can be found in Appendix V.

Table 12: Summary of Aquatic Threatened Fauna for the Rangelands NRM sub-regions and the Rangelands as a whole.

Note that the totals for threatened fauna species are not equivalent to the sum of the sub-region as species may occur in more than one sub-region.

Conservation Code	Kimberley	Pilbara	Goldfields-Nullarbor	Gascoyne-Murchison	Whole-of-Rangelands
Extinct (E)	0	0	0	0	0
Critically Endangered (CR)	0	0	0	5	5
Endangered (EN)	0	0	1	1	1
Vulnerable (VU)	0	9	1	3	12
Priority 1 (P1)	2	0	3	4	9
Priority 2 (P2)	6	2	0	1	9
Priority 3 (P3)	0	0	0	0	0
Priority 4 (P4)	0	1	0	1	2
Priority 5 (P5)	0	0	0	0	0
Other Specially Protected (S)	3	0	0	0	3

2.7.17 Overview of Aquatic Biodiversity in the NRM Sub-regions

Kimberley

Waterways and wetlands in the Kimberley are broadly described as perennial or intermittent rivers, ephemeral wetlands on rock outcrops and seasonal lakes and associated swamps (Lane and McComb, 1988). There are 23 wetlands (including rivers) of national importance and four Ramsar listed wetlands within the Kimberley. The full list of these wetlands can be found in Appendix VIII Attachment 2.

Perennial and intermittent rivers in the Kimberley provide habitat to a variety of fish, crustacean, aquatic reptiles and invertebrates. A notable and popular game fish is the Barramundi (*Lates calcarifer*), which migrates from freshwater river systems to marine waters systems to spawn (catadromous). The barramundi is ecologically, culturally, socially and economically important in the Kimberley and considered an iconic species of the Kimberley.

There are many other inland fish associated with river systems including priority-listed fauna Greenway's Grunter (*Hannia greenwayi*), Long-nose Sooty Grunter (*Hephaestus epirrhinos*), Large-scale Grunter (*Leiopotherapon macrolepis*), Drysdale Grunter (*Syncomistes rastellus*) and Pygmy Rainbowfish (*Melanotaenia pygmaea*) (Western Australian Museum, 2005). The Drysdale River in the Region's north has the richest freshwater fish fauna known in Western Australia with 26 species recorded from the River and its tributaries (Tapin, 2003).

Also of significance is the occurrence of the formally undescribed Northern River Shark (Glyphis species C) and the Freshwater Sawfish (Pristis microdon). The Northern River Shark is endangered (as listed in the *EPBC Act 1999*) and previous occurrences were restricted to Northern Territory and Paupa New Guinea (Thornburn and Morgan, 2004). Numerous surveys (see Thorburn and Morgan, 2004) of the North Western rivers did not record the species yet seven specimens were collected in the macrotidal mangrove systems near Derby. This suggests that the tidal creeks of King Sound are important habitat for the Northern River Shark.

The Freshwater sawfish is listed as critically endangered under the *EPBC Act*. It occurs mostly in fresh or weakly saline rivers in northern Australia including the Fitroy, Durrack and Ord rivers. The freshwater Sawfish grows to at least 280 centimetres making it the biggest freshwater fish in Australia. Freshwater

and esturine habitats of northern Australia seem to be crucial to the survival of this species (J.J. Pogonoski, D.A. Pollard and J.R. Paxton Environment Australia, February 2002*).*

A recent study collected seven specimens in the macrotidal mangrove systems near Derby in salinities close to seawater (32 to 36.6 ppt). It was previously only known in salinities ranging from two to 26 ppt. Thorburn and Morgan suggest that the tidal creeks of King Sound may be important habitat for the Northern River Shark as numerous surveys (see Thorburn and Morgan, 2004) of rivers in northern Western Australia did not record the species.

Other aquatic fauna associated with rivers include the freshwater and saltwater crocodiles (*Crocodylus johnstoni* and *Crocodylus porosus* are specially protected species), freshwater crustaceans such as cherabin or giant freshwater prawn (*Macrobrachium rosenbergii*), amphibia including the priority fauna Small Toadlet (*Uperoleia minima*), freshwater turtles and invertebrate (including several species of molluscs). Whilst there has not been a systematic study of the level of endemism of fauna in the Kimberley, there are at least 16 species of fish and 10 species of frogs that are endemic to the region.

There are at least 30 species of aquatic plants found in the Kimberley. Some plants of interest are *Tristicha trifaria (australis?),* an unusual plant that grows in fast flowing water, and *Aldrovanda vesiculosa*, a carnivorous plant that floats on the water, both of which are found at Mitchell Falls (Tapin, 2003).

Wetlands in the Kimberley generally are seasonal unless water supply is abundant enough to maintain levels during the dry season or maintained artificially such as at Lake Kununurra and Lake Argyle. Many aquatic species have adapted to the seasonal drying out of wetlands. Many frogs have rapid reproduction cycles during the wet months whereas some shrimps breed as the climate begins to dry producing drought resistant eggs that hatch once the new rains come. Other animals use burrowing to survive the dry period, producing a protection barrier against evaporation (eg. Northern Burrowing Frog *Neobatrachus* aquilonius) or using hibernation techniques such as aestivation (eg Northern Long-Necked Turtle *Chelodina rugosa*) (Western Australian Museum, 2005).

Aquatic invertebrates play a vital role in both riverine and wetland systems. They are an important part of the food chain as well as playing an important role in the breakdown of organic material. Seasonal wetlands are colonised by terrestrial plants during the dry, and then when the wetlands re-inundate during the wet, macro-invertebrates process this organic material turning it into a ready food source for many other animals, including waterbirds.

Waterbirds are an important component of aquatic ecology, which help maintain balances of invertebrates and facilitate the transport of genetic material between wetlands (eggs, invertebrates and micro-organisms contained in mud). They are also very dependent on wetlands for feeding, roosting and breeding.

Riparian vegetation plays an important role for aquatic environments by providing bank stability, shade, food, biofiltering and habitats for a range of aquatic fauna. There are several “Wild Rivers” in the Kimberley, which have riparian vegetation in good to excellent condition. These areas of relatively un-impacted riparian vegetation have significant values for ecological and scientific purposes.

Pilbara

The Pilbara occurs in the northern reaches of the Indian Ocean Drainage Division. Large river systems and numerous riverine and rock pools form complex inland ranges, plateaus and extensive coastal plains in the western proportion of the Pilbara. The Great Sandy Desert makes up the majority of the eastern half of the Pilbara and contains scattered occurrences of minor spring wetlands and lake systems, soaks, salt lakes and underground aquifers. Twelve wetlands of national importance either completely or partially occur in the Pilbara (see Appendix VIII Attachment 2 for full list).

A number of native fish species occur through the western Pilbara including Blue Catfish (*Arius graeffei*), Indian Short-finned Eel (*Anguilla bicolour*), Bony Bream (*Nematalosa erebi*), Flathead Goby

(*Glossogobius giuris*), Hyrtl's Tandan (*Neosilurus hyrtlii*), Western Rainbowfish (*Melanotaenia australis*), Barred Grunter (*Amniataba percoids*), Fortescue Grunter (*Leiopotherapon aheneus*), Spangled Perch (*Leiopotherapon unicolour*), Murchison River Hardhead (*Craterocephalus cuneiceps*), Empire Gudgeon (*Hypseleotris compressa*), Barramundi (*Lates calcarifer*), Blind Cave Eel (*Ophisternon candidum*) and Blind Gudgeon (*Milyeringa veritas*) (Western Australian Museum, 2005, Morgan and Gill 2004). Both the Blind Cave Eel and Blind Gudgeon are listed as threatened species (vulnerable) and the Fortescue Grunter is listed as a priority four taxa under the *Wildlife Conservation Act 1950*.

Morgan and Gill (2004), in a recent study of the Pilbara Drainage Division (from the Greenough River in the south to the De Grey River in the North) suggested three sub-provinces are evident in the distribution of inland fish fauna species. The Northern Pilbara sub-province occurs from the Yannarie to De Grey Rivers thus primarily occurring in the Pilbara. The Southern Pilbara and North West Cape sub-proinces occur in the Gascoyne-Murshison. The waters of Northern Pilbara sub-province housed 11 fish species (dominated by tropical groups) including one endemic species (Fortescue Grunter) compared with four species in the southern sub-province. An important finding of the study was the absence of introduced fish species north of the Lyndon River.

Other aquatic fauna include freshwater turtle (eg Flat-shelled Turtle, *Chelodina steindachneri*), a number of frogs from the families Hylidae (eg. Giant Frog, *Cyclorana australis* and Green Tree Frog, *Litoria caerulea*) and Myobatrachidae (eg. Spotted Tree Frog, *Limnodynastes spenceri* and Douglas Toadlet, *Pseudophryne douglasi*, both of which are endemic to Western Australia) (Western Australian Museum, 2005).

A biological survey conducted by CALM of five springs on the Fortescue, Ashburton, Robe and De Gray Rivers collected 141 species of aquatic invertebrates (Halse, 2002). This study also discovered 18 species of stygofauna collected half a meter below the surface. Previously stygofauna was only known to occur between 10 to 40 meters depth in groundwater associated with calcrete in riverbeds (Halse, 2002). Recent analyses have revealed new species of stygofauna and further studies are continuing as part of the Pilbara Biological Survey undertaken by CALM and the WA Museum. Though survey work in this area has been limited to date, there is a high likelihood that arid areas of the Pilbara would exhibit high levels of endemism within the troglofauna associated with calcrete systems along ancient palaeo-drainage lines (Kendrick, 2001).

Gascoyne-Murchison

The Gascoyne-Murchison covers the southern half of the Indian Ocean Drainage Division. Two major river systems occur in the sub-region, with the Murchison River mouth located in the northern agricultural district. Two minor rivers, the Minilya and Wooramel Rivers, flow into Lake McLeod and Hamlin Pool respectively. Eleven wetlands of national importance occur in the Gascoyne-Murchison (see Appendix VIII, Attachment Two). The northern section of Lake MacLeod has been nominated with high priority for Ramsar listing.

All rivers in the sub-region flow intermittently, relying on significant seasonal rainfall events for large flows. Due to the seasonal nature of river flows in the region, pools and billabongs are important refugia for aquatic biodiversity species. Significant flow events reconnect otherwise isolated pools allowing for rejuvenation of organic materials from other pools and riparian areas (channel/ floodplain exchanges) and genetic resources (connectivity of separate populations) (Water and Rivers Commission, 2000).

Native fish found in the Gascoyne-Murchison include the Murchison River Hardyhead (*Craterocephalus cuneiceps*), Golden Gudgeon (*Hypseleotris* aurea) , Spangled Perch (*Leiopotherapon unicolour*) and Empire Gudgeon (*Hypseleotris compressa*) (Western Australian Museum, 2005). The Golden Gudgeon is listed as priority two taxa under the *Wildlife Conservation Act 1950* and is regionally endemic to the Gascoyne and Murchison Rivers (Morgan and Gill 2004).

The Gascoyne-Murchison typically is within the Southern Pilbara sub-province for inland fish fauna suggested by Morgan and Gill (2004). Only four species of native fish species were collected in the southern sub-province during this study and the distribution of introduced fish did not extend north of the Lyndon River. This implies that all of the introduced fish species collected in the study (~39 percent of

specimens), were found in the Gascoyne-Murchison. The threat of introduced pest fish species is high with the occurrence of *Tilapia* spp., a large vigorous, mouth brooding fish genus, found in all Gascoyne-Murchison catchments except the Murchison and Wooramel. Morgan and Gill (2004) propose that introduced species have contributed to the decline of native fish species. Evidence for this can be seen

in the decline of the Murchison Hardyhead and Golden Gudgeon in the Gascoyne River where *Tilapia* spp. occur in contrast to the Murchison River, which is free of introduced species. However, in the absence of abundance data for these native species in the Gascoyne prior to the introduction of exotic fish species this cannot be confirmed.

There have been two major studies of aquatic invertebrates in the Gascoyne-Murchison: CALM's Southern Carnarvon Basin biological survey (Halse *et al.*, 2000) and sampling done for the Monitoring River Health Initiative (Kay *et al.*, 1999; Halse *et al.*, 2001). The Carnarvon Basin work shows that the invertebrate fauna of an area between the Murchison and Minilya Rivers, within 100 to 150 kilometres of the coast, contained more than 500 aquatic invertebrate species. About half were micro-invertebrates (small crustaceans –cladocerans, ostracods, copepods – rotifers and protozoans) and the other half were largely insects (chironomid midges and other fly larvae, beetles, bugs, dragon- and damselflies, and several groups of specialist aquatic insects) but included mites, worms, molluscs and some larger crustaceans. It was not possible to assess the proportion of species restricted to the sub-region but it was probably low. From the viewpoint of conservation planning, one of the most important features of the fauna is the low frequency of most species and their patchy and unpredictable occurrence.

The River Health work in the sub-region involved sampling of all major rivers for macro-invertebrates. Animals were identified only to family but 71 "families" (this definition is a bit loose) were collected. Most families are widespread in Western Australia and none were restricted to the Gascoyne-Murchison. Using macro-invertebrates to assess river health, the Lyndon-Minilya system and Murchison appeared to be relatively degraded, while the Gascoyne and Wooramel were in better condition (although by no means undisturbed). It is interesting that this pattern is very much driven by the results of sampling in autumn – the results of sampling in late winter show a much more 'natural' macro-invertebrate fauna. The conclusion at the time was that winter flow events re-set rivers, improving river condition and ecology. The same is probably true of late summer river flow.

During drier periods, the river systems of the sub-region contract to a series of non-flowing, semi permanent waterholes that carry much of the aquatic fauna through to times of rainfall and higher river flow. If these water holes are not managed in an environmentally sustainable manner there is a high risk of destroying the fragile riparian vegetation. This has the potential to change stream variables such as water temperature and turbidity which impact on the survival of stream biodiversity.

The groundwater of the Cape Range region is very significant as a karst environment supporting a suite of subterranean fauna of significant conservation value. The Cape Range karst system is of international significance and has been recognised as having potential for Ramsar listing. Two such suites have been identified as being threatened ecological communities, Bundera Sink Hole and Camerons Cave, as the town of Exmouth and the surrounding infrastructure also draw water from this groundwater resource. These are the only two TECs in the Rangelands that have recovery plans in place.

Wetlands range from marine and coastal zone wetlands (eg. Hamlin Pool) to karst cave systems (eg Bundera Sink Hole) to saline wetlands (eg Wagga Wagga Salt Lake) to inland freshwater systems (eg Wooleen and Breberle Lake). A number of wetlands of sub-regional importance are identified in the *Biodiversity Audit of Western Australia's 53 Biogeographical Sub-regions*.

Goldfields-Nullarbor

The Goldfields-Nullarbor is largely within the Western Plateau Drainage Division and is dominated by an arid climate. Subsequently, there is an absence of major rivers and drainage is typically internal. Eleven wetlands of national importance occur in the sub-region (see Appendix VIII, Attachment 2 for full list).

Although there has been a lack of a systematic aquatic biodiversity survey in the Goldfields-Nullarbor, some information is available. These preliminary findings and those of the high aquatic invertebrate species diversity from the Pilbara Biological Survey (S. Halse 2005, *per. comm*. 5 February), suggest the aquatic habitats have significant conservation value.

Native inland fish species are uncommon with some occurrence of common galaxias (*Galaxias maculatus*) recorded. A number of frog species occur in the sub-region (most at the extreme of their known range) including Mains Frog (*Cyclorana maini*), Water-holding Frog (*Cyclorana platycephala*), Northern Burrowing Frog (*Neobatrachus aquilonius*), Kunapalari Frog or Wheatbelt Frog (*Neobatrachus kunapalari*), Desert Spadefoot (*Notaden nichollsi*) and Western Toadlet (*Pseudophryne occidentalis*) (Western Australian Museum, 2005).

The stygofauna communities of the calcrete aquifers in the northeast Goldfields contain the world's most diverse assemblage of subterranean diving beetles with over 80 species now described. Each species is endemic to a single aquifer, and the same patterns of endemism occur in amphipods and isopods, suggesting the calcrete aquifers are like subterranean islands. The aquifers are potentially under threat from water abstraction by mines and pastoralists, and the use of calcrete as a resource in mining operations and road construction (Steve Cooper 2005, *pers comm.*) The Depot Springs stygofauna community has been listed as a threatened ecological community. Some data exists on the stygofauna communities in the karst systems of the Nullarbor Plain and specimens are opportunistically collected by cave divers, but knowledge of this group is generally poor.

Ecological research and monitoring of around 15 different salt lakes are also being undertaken by Outback Ecology Services in collaboration with various mining companies to ensure their biodiversity values are not compromised by mining discharge (Stacey Coxall, 2005, *pers comm.*). Recent work indicates a high level of endemism and high species richness in the crustacean component (S. Halse, *per. comm.*) of the inland aquatic ecosystems.

2.7.18 Major Uses and Values of Aquatic Biodiversity

Conservation Use

Aquatic biodiversity is essential to the function of hydrological systems. For instance, riparian vegetation provides stability to river channels and banks, filters out excessive nutrients, chemicals and sediment in runoff entering rivers and wetlands, and provides habitat, shade and recreational qualities. Biodiversity within water plays an important role in the breakdown of organic material to its most basic form and in capturing energy and providing food for other fauna.

These ecosystem services have many flow-on effects and benefits to other elements of biodiversity and humans such as providing clean water, enriching floodplains with nutrients and fulfilling recreation, aesthetic and cultural needs. These values are worthy of conservation for ethical and practical reasons and hence there are a number of management mechanisms such as Ramsar, international treaties (eg JAMBA, CAMBA), the Directory of Nationally Important Wetlands, State Wetlands Conservation Policy for Western Australia and position statements from the Environmental Protection Agency that aim to protect aquatic biodiversity integrity. There is also a commitment in the Wetlands Conservation Policy for Western Australia 1997 to adequately protect a representative sample of wetland types found in Western Australia. In order to achieve this, wetlands types need to be represented within a formal CAR reserve system, that is, a reserve system that has a comprehensive sample of ecosystems, provides adequate protection (long term viability) and is representative of the variations within ecosystems.

Commercial Inland Fisheries

For commercial inland fisheries, the State is divided into the northern and southern inland bioregion at 27° latitude. The only commercial inland fishery occurs in the northern bioregion, the Lake Argyle freshwater Catfish Fishery, which targets the catfish or “Silver Cobbler” (*Arius midgleyi*) and is managed by a set of licensing conditions. Inland waters are nursery grounds for some commercial salt-water fisheries such as Barramundi and Mangrove Jacks.

Inland Aquaculture

Barramundi farming in the northern inland bioregion occurs in Lake Argyle and in reticulating systems in areas further south.

Additionally aquaculture using sub-surface and artesian water is being investigated as a diversification option by a number of pastoral enterprises. This investigation has seen three pilot aquaculture facilities and a training and research facility established in the Carnarvon and Shark Bay areas. For a number of years these facilities have trialed the production of freshwater finfish and aquarium fish. More information can be obtained through the Gascoyne Inland Aquaculture Group.

Recreational Inland Fisheries

The popularity of Barramundi fishing in inland waters in the northern inland bioregion places significant pressure on Barramundi stocks (Department of Fisheries, 2003). New management arrangements were set in place in 2002 to restrict recreational Barramundi fishing by reducing the catch limit from five to two and conservation areas for Barramundi have been allocated in the Ord and Fitzroy Rivers and in the Broome area.

Inland recreational fishing also includes other fish species such as Mangrove Jack (*Lutjanus argentimaculatus*) (in the lower reaches of rivers), Sooty Grunter, Bony Bream and Cherabin (Giant Freswwater Prawn, *Macrobrachium rosenbergii*).

Indigenous Use and Value

Aboriginal people have strong cultural and spiritual connections with rivers and wetlands and aquatic biodiversity. In remote areas rivers and fish are important to traditional life, being a food source and a part of traditional practices. Fish, for example, are an alternative food source when there is a red meat ban after a death in the family, or a way of entertaining visiting relatives and can also supplement food sources in areas that experience low income. Fishing also is important in imparting traditional knowledge and skills to new generations through activities such as fish traps, poisons and spears.

There is a risk of loss of traditional knowledge due to a lack of documentation (given the oral and participative nature of traditional learning) and the low motivation of younger generations to learn traditional ways. There is also a need for policy and legislation to recognise and account for traditional fishing.

The *Aboriginal Fishing Strategy* discussion paper was released in 2004 and a draft strategy is currently in consideration in State Parliament. Consultation was undertaken throughout the State using a process developed by the Aboriginal Fishing Strategy Working Group. The strategy focuses on two objectives:

- the inclusion of traditional and cultural fishing practices within a framework of planned sustainable use of fish and fish habitat; and
- greater involvement of Aboriginal people in the fisheries sector, including commercial fishing, aquaculture, the aquatic charter industry, and fisheries management.

2.7.19 Major Threats to Aquatic Biodiversity

Numerous processes threaten the ability of aquatic biodiversity to sustain ecological functions in rivers and wetlands. Generally these result from human activities that impact on the water that organisms inhabit or on the organisms themselves. Below is an overview of some of the major threatening processes that occur (either partially or entirely) in the Rangelands.

Climate Change

Changes in climatic conditions may result in higher rainfall in summer that evaporates and creates a water deficit, increases temperature and catastrophic event such as cyclones and flooding. Such

changes would have a significant impact on aquatic biodiversity and there is the need to do further work to assess the impacts of climate change, and to identify management actions to minimise it impact.

Alteration of Natural Water Regimes

On a catchment level, changes to water regimes are influenced by clearing native vegetation and land degradation, which reduce infiltration and increase run off. This may lead to erosion and contribute to floods and sedimentation. On a local scale, water source development, drainage works, infrastructure (roads, railways, river crossings), free flowing artesian bores, mine voids and mine dewatering and discharge alter surface water and groundwater regimes. Dewatering can result in a wetland totally drying out resulting in the loss of habitat of aquatic stygofauna.

Changes to the natural flow of waters or groundwater levels can impact on aquatic organisms that rely on particular hydrological regimes. Activities that can alter natural water regimes include damming of major rivers, abstraction for irrigated agriculture, groundwater abstraction for water supply, mine dewatering and diversion of waterways. Such activities can lead to reduction in flows and flooding levels and subsequent reduction and change in the composition of riparian and wetland vegetation, and in turn reduced habitat, refuge areas and food resource for aquatic organisms.

Stygofauna communities in the Cape Range karst systems are an example of aquatic organism at risk of altered natural water regimes. The town of Exmouth draws water from the Exmouth Groundwater sub-area, potentially altering groundwater levels and modifying the habitat of aquatic taxa. In this instance, two stygofauna communities have been identified as TECs and have Interim Recovery Plans in place. Mining can also have similar effects on cave communities through dewatering activities.

Fish passage along waterways is critical to the survival of Australian native fish. Species of both freshwater and saltwater fish move within waters at different times to access food and shelter, to avoid predators, and to seek out mates to breed and reproduce with. Migration is often a necessary part of fish life cycles and can occur at various life stages such as the need to reach particular habitats for breeding, recruitment or spawning. Many native fish in the arid Rangelands are dependent upon migration to deeper pools for survival in times of declining water levels whilst some, such as Barramundi, are dependent upon migration to reach spawning areas, and for juvenile recruitment.

Fish barriers can occur from artificial physical blockages such as dams, weirs and floodgates or the alteration of natural flow conditions due to waterway crossings and culverts. These barriers can stop fish from breeding and repopulating waterways or can otherwise waste precious energy required for their survival and reproduction through negotiating barriers. Where barriers stop fish from migrating, such as the Barramundi upstream of tidal barrages in tho Ord and the Fitzroy Rivers, local extinction can result.

Altered Water Quality

Water quality can greatly affect the health of aquatic biodiversity. Water quality generally refers to the chemical make-up of the water and clarity of the water. Chemical effects on water quality include toxic contamination by chemicals, increased salinity levels and increased nutrient levels. These change the chemical environment in which aquatic organisms live, usually to their detriment but (particularly with regards to nutrients enrichment) can lead to toxic accumulation of chemicals in some organisms, un-natural levels of reproduction in some organisms (eg blue-green algae) and an imbalance in natural ecosystems (Ball, 2001).

Mine voids become point sources for hypersaline water, which potentially impacts on local groundwater systems. Long term water quality impacts are difficult to predict. Post mine closure management plans are helping to address this issue.

Clarity of water is important for light penetration into the water column and photosynthesis. Excess sediment in runoff waters can reduce clarity of water and shade aquatic plants reducing growth rates or causing deaths. This can lead to de-oxygenation of the water column causing further pressure to aquatic organisms.

Excess sediment also leads to the infilling of pools, and this is a particular problem for permanent pools that are the only water source during extended dry periods.

Overgrazing of Wetlands and Riparian Vegetation

Where there is a concentration of grazing, conflict between the use of wetlands and rivers as watering points for domestic stock and the protection of riparian and aquatic vegetation given the scale of river fronts occurs in some pastoral areas. Total grazing pressures on riparian vegetation and seasonal wetlands can reduce vegetation density and cover exposing fragile soils to erosional forces.

Riparian zones are naturally exposed to episodes of disturbance and regeneration but increased grazing pressure has disturbed this balance. Wetlands, rivers and other waterbodies, particularly those of a seasonal nature, are sensitive to grazing, leading to trampling of vegetation, compaction of soils, introduction of weeds, changes in composition, and increased nutrients from faecal matter.

Several wetlands of national and sub-regional importance occur on pastoral leases that do not have current management plans to mitigate impacts such as grazing pressure. There is a need to identify those wetlands of significant biodiversity value and implement cooperative action to manage the impacts of grazing.

Exotic Plants and Animals

Exotic plants such as Mesquite, Parkinsonia, Noogoora Burr and Buffel Grass can quickly colonise riparian areas (Department of Natural Resources and Mines, 2003) where native riparian vegetation has been disturbed or is in a degraded state. Rivers are efficient conduits for further spread of such weeds once they become established. Serious invasions of weeds in riparian areas can lead to increased fire loads, displacement of native plants, reduced habitat for animals and increased organic pollution (Water and Rivers Commission, 2000). The occurrence of exotic weeds in river and wetland areas in the Rangelands is not well known or documented and there are no statewide or Rangelands wide programs to deal with environmental weeds.

Animals are drawn to water sources and can significantly impact on aquatic biodiversity. Trampling and destruction of wetland and riparian vegetation can be caused by domestic stock, goats, pigs, camels and donkeys. Other animals such as rabbits place heavy grazing pressures on new growth reducing regeneration and seasonal growth in ephemeral wetlands. Animals can also increase soil erosion, which leads to turbidity in the water column, reducing light for primary production by aquatic plants and algae, thus decreasing energy capture within aquatic systems.

Ten species of introduced fish occur in Western Australia, four of which (Mosquito Fish, *Gambusia holbrooki*, Tilapia, *Oreochromis mossambicus*, Swordtail, *Xiphophorus* hellerii and Guppy, *Poecilia reticulata*) (Morgan *et al*., 2004) occur in the Gascoyne-Murchison. Rivers north of the Lyndon and east of the Pallingnup (south coast) are free of introduced species (Morgan *et al*., 2004). Species such as Tilapia (*O. mossambicus*) can compete with native species for available habitat. For example, Morgan and Gill (2004) found that Tilapia often covered up to 80 percent of shallows in pools on the Gascoyne River with nests that were viscously guarded by the incumbent males. This exclusion is highly likely to have deleterious effects on native species. More research is needed on the impact of introduce redclaw on native species such as cherabin.

Cane toads are a significant threat to aquatic and other biodiversity, and whilst it is not currently at large in Western Australia, it is predicted that their migration into the northern end from Queensland, where it was first introduced, will likely see them in Western Australia in the 2006/ 2007 or 2007/ 2008 (Chance, 2004). Currently the known front of cane toad migration occurs at Victoria River in the Northern Territory, approximately 300 kilometres from the State border. The spread of cane toads is a major threat to the biodvieristy of the high value, pristine and near pristine wetlands in the Kimberley.

Tourism and Recreation

Tourism and recreation also have localised impacts. In the Pilbara and Kimberley most tourism and recreational locations are along rivers or permanent water holes, particularly main road travel stops. Unrestricted access to the river banks concentrates activity in small locations, where water quality can be reduced and riparian vegetation damaged through firewood abstraction, trampling and compaction and erosion of the foreshore area.

Impacts of tourism to karst systems include acclerated erosion around dolines and direct impact to fauna and future threatened ecological communities in cave entrances and twilight zones.

2.7.20 Current Management of Aquatic Biodiversity

State Government

The State Government has outlined 62 actions in the *Wetlands Conservation Policy for Western Australia 1997* that will contribute to the conservation of aquatic biodiversity by improving planning, knowledge and appreciation of wetland values. The implementation of this policy is achieved through the establishment of the State Wetlands Committee comprised of government, scientists and community representatives.

Examples of the policy being implemented include biological surveys to fill substantial knowledge gaps in current knowledge (CALM and Western Australian Museum), water quality monitoring programs (Department of Environment) and representation on the National Wetlands and Waterbirds Taskforce (advising committee to the Natural Resource Management Ministerial Council).

The Department of Environment has a role in managing water, wetlands and waterways through various programs including compliance monitoring of industry, river level monitoring, Ribbons of Blue community education programs (eg Lower Gascoyne, Kimberley), provision of advice on restoration of waterways and wetlands and environmental water provisions. For example, work is occurring on Cape Range to determine the environmental water requirements for the karst cave systems and stygofauna.

CALM is involved in recovery programs for karst cave TECs on Cape Range for two communities of stygofauna. There are also a number of aquatic fauna species in the Rangelands on the State threatened fauna list. The majority of these are cave dwelling fauna (*Nedsia* spp. on Barrow Island) but it also comprises priority listed species of toadlets (eg Marbled Toadlet, *Uperoleia marmorata* and Small Toadlet, *Uperoleia minima*) and native fish (eg Pygmy Rainbowfish, *Melanotaenia pygmaea* and Fortescue Grunter, *Leiopotherapon aheneus*).

Project Work

There are a number of projects occurring throughout the Rangelands that either relate directly to aquatic biodiversity or have biodiversity outcomes.

The Kimberley Land Council (KLC) is working with WWF and Murdoch University on a Threatened Species Network Project looking at the Freshwater Sawfish (*Pristis microdon*). The Sawfish is threatened by fishing (bycatch), loss of habitat and potential development of the Fitzroy River. The project provides training to Indigenous groups to conduct surveys for the Sawfish and discuss its cultural importance. The project will also work closely with the Department of Fisheries in its development of a National Recovery Plan in collaboration with the Australian Government Department of Environment and Heritage.

Also in the Kimberley, a study is being undertaken into the construction of a fishway on the Camballin Barrage, which is no longer is in use, and presents an obstacle to the migration of fish species up the Fitzroy River. The study has been funded by Land and Water Australia in association with the Department of Environment and Murdoch University.

Murdoch University is working with the KLC, supported by funding through the Australian Government Department of Agriculture, Forestry and Fisheries to record the traditional language names for fish and build community capacity and awareness in the West Kimberley. The University is also conducting research on the Northern River Shark (*Glyphis* sp. C) and recently completed research on the distribution of inland fish species in the Pilbara (Indian Ocean) Drainage Division (Morgan and Gill, 2004).

There are two components to the Pilbara Biological survey, surface water and stygofauna. Work on aquatic biodiversity in the Pilbara biological survey is continuing and is due to be completed in 2007. More than 20 staff from CALM, with assistance from the Western Australian Museum, are surveying 800 sites within the Pilbara bioregion. Work on aquatic biodiversity is divided into two components of surface water and stygofauna in the Pilbara Biological survey. Results so far have shown that species richness of invertebrates in surface water to be as high as 140 species and the richest assemblages known from Australia.

Research projects are currently underway into the diversity and endemicity of the stygofauna within the calcrete aquifers of the Goldfields-Nullarbor, involving the Western Australian Museum, South Australian Museum, the University of Adelaide, Newmont Australia and Placer Dome Asia Pacific.

Project work in the Gascoyne-Murchison and Goldfields-Nullarbor has been relatively low in comparison to the Pilbara and Kimberley. There is a general lack of knowledge of aquatic biodiversity and wetland types in these sub-regions and it is likely that project work will be a high priority for the future.

2.7.21 Aquatic Biodiversity RCTs and MATs

RCT14: Maintain or improve the conservation status of aquatic and riparian native species and assemblages in priority waterways, wetlands and groundwater by 2025

RCT15: Eradicate or reduce the abundance and distribution and limit new occurrences of ecologically significant invasive aquatic and riparian species by 2025

Management Action Targets		Geographic Focus	Actions	Potential Partner Groups	Links to RCTs	Priority
Benchmarking and Monitoring						
8 	**W15.** By 2010 identify and prioritise areas of high conservation, aesthetic and intrinsic values and identify potentially threatening processes	Regional Priority Areas	• Review and collate relevant information • Identify and address knowledge gaps • Prioritise wetlands, waterways and groundwater • Prioritisation to guide current and future management plans, actions and processes to recognise and protect these values • Undertake traditional and cultural surveys and monitoring programs • Increase knowledge on waterways extent, values and threats • Monitor specific impacts of threatening processes on important species and aquatic and riparian system health • Support programs to monitor impacts of fire, invasive species, threatened species, iconic species, fishing impacts and tourism • Development and implement monitoring programs	Research State Local Gov Community Industry Traditional Owners Native Title Representative Body	RCT14 RCT15	3A
8 	**W16.** By 2010 determine benchmark indicators for aquatic and riparian system health	Priority Areas	• Develop techniques for aquatic and riparian system health indicators suitable for regional scale assessment of flood plain management, river flow and riparian vegetation. • Develop benchmarks for monitoring ground water dependent communities • Implement monitoring of priority ground water communities • River flow and EWRs	State Local Government Industry Traditional Owners	RCT14 RCT15 RCT1	3B

Management Action Targets		Geographic Focus	Actions	Potential Partner Groups	Links to RCTs	Priority
8 	**W17.** Investigate and research the distribution, abundance and ecological requirements of aquatic flora and fauna populations in priority areas for management purposes by 2010	Site specific Priority areas	• Conduct investigative flora and fauna surveys for priority areas • Comprehensive surveys undertaken where warranted • Survey/classify species and ecological communities • Map aquatic habitats using remote sensing and GIS techniques • Identify priority areas for management • Undertake detailed assessments of the interaction between ground water abstraction and associated dependant ecosystems	State Local Government Industry Traditional Owners	RCT14	3B
11 	**W18.** By 2010, there is an increased understanding of the impacts of climate change on waterways, wetlands and groundwater systems	Site specific Priority areas	• Models are developed to assist in predicting changes in climate The consequences of climatic variables are incorporated into resource management planning processes (to be ascertained from predictive models and indices) • Changes in catchment hydrology are monitored	State Local Government Industry Community Traditional Owners	RCT14 RCT15 RCT1	1C

Management Action Targets		Geographic Focus	Actions	Potential Partner Groups	Links to RCTs	Priority
On-ground Action						
11 	**W19.** Implement management plans for 8 priority wetlands and waterways and high use areas to reduce impacts on aquatic system health by 2010	Site specific Priority areas	• Two plans developed per subregion • Develop guidelines for Irrigation, Pastoral, Tourism & Recreation, Mining, Fishing & Aquaculture in consultation with relevant stakeholders • Develop protocols for tour operators in the appropriate use of Aboriginal cultural information in marketing campaigns and tourism products in consultation with relevant stakeholders • Involve relevant stakeholders in the development and implementation of Management Plans • Access guidelines developed in partnership with relevant stakeholders • Improvement of perennial, deep rooted vegetation on river and creek banks and around springs to reduce erosion and sedimentation of waters • Determine and mitigate impacts of large animals on wetland degradation • Review the adequacy of current and proposed formal reserves for protection of priority aquatic habitats (including wet caves) and catchments • Encourage the secure management of unprotected aquatic habitats for conservation off reserve e.g. Joint management, IPA, private off reserve conservation. • Catchment management plans to protect high value rivers, river reaches and wetlands to address different land uses • Protect 'Wild Rivers' catchments • Utilise scientific and traditional knowledge	State Local Government Industry Community Traditional Owners	RCT5 RCT14 RCT15	1A

Management Action Targets		Geographic Focus	Actions	Potential Partner Groups	Links to RCTs	Priority
8 	**W20.** Implement 5 Recovery Plans for threatened aquatic species and ecological communities by 2010	Priority areas	• Implementation of Recovery Plans for threatened species and threatened ecological communities • Conduct research into priority flora and fauna to determine status • Make necessary nominations for addition to threatened list • Implement threat abatement plans • Continue the implementation of recovery plans • Assess the need and effectiveness of establishing breeding and propagation programs for threatened and endangered species • Develop habitat management plans for significant species and communities (e.g. regional endemic, migratory and iconic species) • Develop models for threatening processes affecting priority significant species and ecological communities	State Local Government Industry Community Traditional Owners	RCT14 RCT15 RCT1 RCT11 RCT12 RCT13	3A
8 	**W21.** Implement four control programs to reduce the abundance and distribution of significant invasive species in priority wetlands and waterways by 2008	Priority areas	• Identify invasive species of significance • Identify priority eradication and control areas • Eradicate or reduce the impacts of identified significant species in priority aquatic systems • Establish partnerships with landholders and Government agencies to improve coordination • Improve capacity of landholders to eradicate or control invasive species • Implement mitigation measures including education programs to prevent the reoccurrence or spread of significant invasive species in priority areas throughout Gascoyne-Murchison	State Local Government Industry Community Traditional Owners	RCT15	3A
Institutional Frameworks, Planning and Policy						
12 	**W22.** Ensure Legislative/ statutory protection and management for all priority waterways and wetlands by 2010	Regional	• Review adequacy of current International, National, State and local statutory protection • Apply Statutory tools to achieve protection and/or restoration of waterways and wetlands • Formalise protection of Wild River catchment through legislation or management plans in consultation with landholders • New artificial structures are assessed to reduce interference with fish migration on waterways	State Local Government Industry Community Traditional Owners NGOs	RCT13 RCT14 RCT15	1B

Management Action Targets		Geographic Focus	Actions	Potential Partner Groups	Links to RCTs	Priority
12 	**W23.** By 2010 develop management plans for five nationally important wetlands across the Rangelands and a number of regionally significant wetlands on a priority basis	Regional	• Develop management plans for wetlands of National and International Importance by 2006 to conserve the biodiversity and cultural values (e.g. migratory birds) • Develop management plans for 50% regionally significant wetlands (as identified in consultation with stakeholders) by 2010 • Assess, document and nominate additional wetlands to the national Directory of Important Wetlands • Community driven Ramsar management plans developed at all Ramsar sites	State Federal Industry Community Traditional Owners NGOs	RCT1 RCT13 RCT14 RCT15	1B
Education, Awareness and Further Engagement						
	See MAT L17					
Cultural Heritage						
13a 	**W24.** Aboriginal fishing management integrated on sector, regional or fishery basis into mainstream management plans by 2008	Regional	• Implementation of the Indigenous Fishing Management Strategy • Capture local knowledge	State Gov Local Gov Industry Community Traditional Owners NGOs	RCT14 RCT15 RCT1 RCT2	2B
	See MATs L18, L19 L21					

2.8 Seascapes

2.8.1 Introduction

This section outlines the major natural resource assets of the Rangelands' seascapes, which are described for:

- coasts and islands; and
- marine waters.

The Rangelands coast is made up of two separate parts with a combined distance in excess of 11,000 kilometres:

- the Gascoyne, Pilbara and Kimberley coasts, which lie between the Western Australian/ Northern Territory border and Kalbarri, and adjacent islands; and
- the Nullarbor coast, which lies between Eucla and the eastern boundary of Esperance, and adjacent islands.

For the purposes of this document, the term "coasts" covers from high tide mark to the landsystems that are strongly linked to, and partially driven by, coastal processes. It should also be noted that coastal biodiversity is partially covered under terrestrial biodiversity and there are overlaps between the resource condition and management action targets of these two sections.

The marine waters area covers from high tide mark to three nautical miles offshore (State waters) as well as offshore islands, and for three nautical miles surrounding them. The natural resources of marine areas in State waters can rely on and move beyond these areas into Australian Government waters, which State agencies involved in NRM have responsibilities for, up to the 200 nautical mile (Economic Exclusion Zone [EEZ]). The marine waters component provides an overview of the organisms and processes that make up the marine biodiversity of Western Australia's Rangelands NRM Region

Appendix I also provides detailed information about major uses and values, and threats of natural resource assets in the sub-regions.

2.8.2 Coasts and Islands

Interim Marine and Coastal Regionalisation of Australia

The coastal and marine resources of the Rangelands can described using major geomorphological (landforms and the processes effecting them) features as outlined in the Interim Marine and Coastal Regionalisation for Australia (IMCRA) (Figure). IMCRA is a national framework for planning sustainable resource and biodiversity conservation in coastal and marine environments and is further described under marine biodiversity. As the name implies, it can be revised as new data and information become available (IMCRATG, 1998).

The following provides an overview of the major coastal geomorphological features and processes within each of the Rangelands NRM sub-regions. This information is based on the description of IMCRA marine and coastal bioregions. IMCRA is used in this section to describe the assets for coasts and coastal waters, and marine biodiversity.

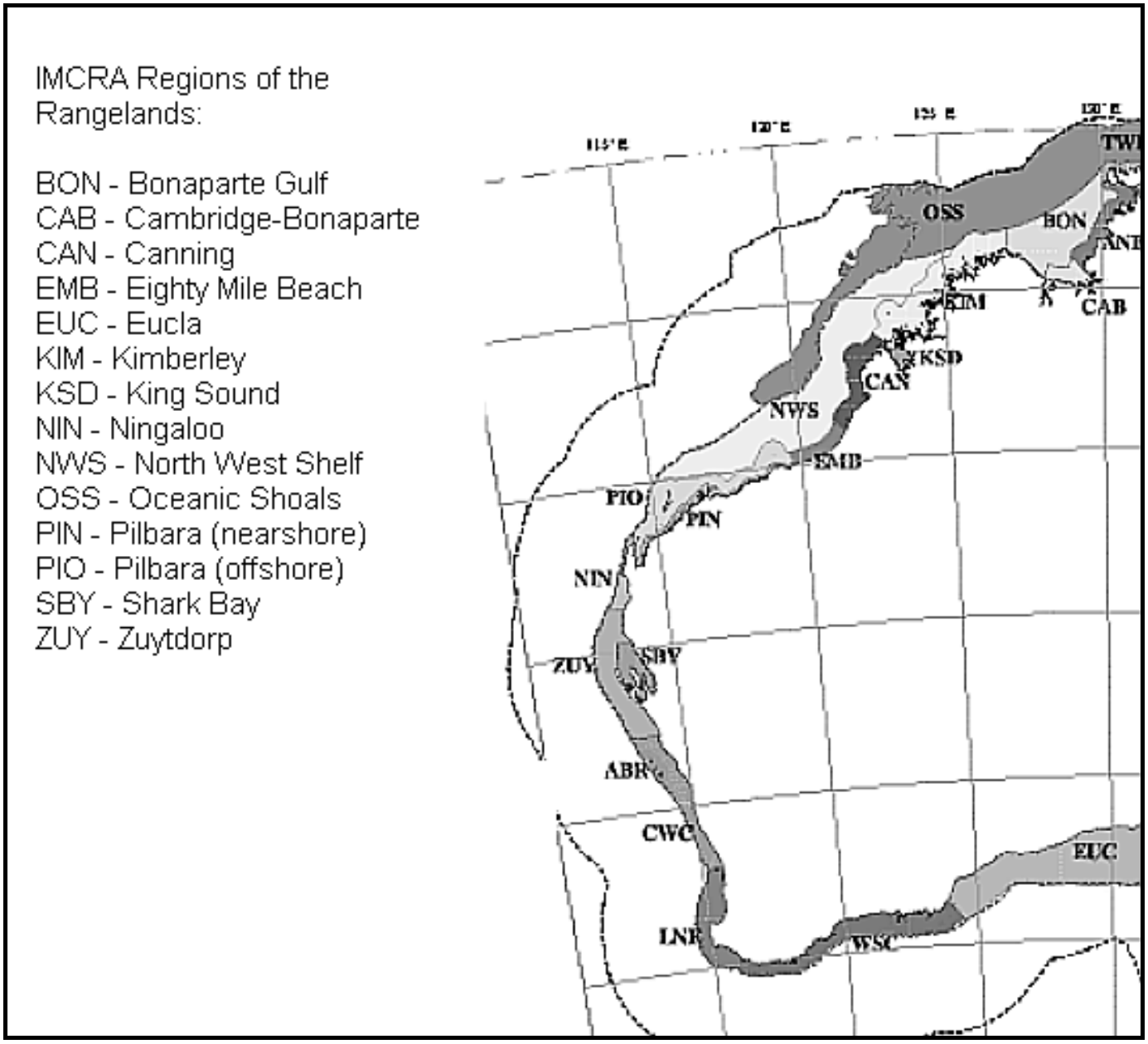


Figure 15: Rangelands IMCRA Sub-regions

Kimberley Coast

The Kimberley coast is approximately 2,500 kilometres in length and one of the most contorted and variable in Australia. It is unique from an Australian perspective due to its large tidal range, with a movement of up to 12 metres driving coastal processes. The coast has been classified into seven IMCRA regions, described below.

Cambridge – Bonaparte Gulfs

This region covers the Cambridge and Bonaparte Gulfs from Cape Dussejour (North of Wyndham) over the Western Australian/ Northern Territory border to Pearce Point from the High Water Mark to the 30 metre depth contour.

It comprises the headwaters of Joseph Bonaparte Gulf, a broad, open marine gulf straddling the Western Australian/ Northern Territory border. At its head are two major seasonal estuarine systems – Cambridge Gulf (Ord, Kiing, Pentecost, Durack and Forrest Rivers) on the Western Australian side, and

a complex of three estuaries (Keep, Victoria and Fitzmaurice Rivers) on the Northern Territory side. They are separated by stretches of low profile shore, backed by salt flats.

Most coastal access is via Wyndham. There is very little other coastal access due to the rough terrain. The land to the northwest of Wyndham is ALT land; to the northeast is nature reserve (False mouths of the Ord) and pastoral leases to the east.

Bonaparte Gulf

This region runs from Cape Londonderry (near Kalumburu) to Cape Dussejour (north of Wyndham) and then offshore to the Northern Territory. It consists mostly of the offshore waters of the Bonaparte Basin deeper than the 30 metre isobath. Sediments are dominated by biogenic gravels and sands grading to biogenic muds offshore. Biological knowledge of the area is poor, except for trawl by-catch data, indicating that fish assemblages are distinctly different from those of the Arafura (ARA) Region to the east.

There is medium fluvial runoff, medium wave action and large tidal ranges. There is no coastal access due to the rough terrain and tenure is Aboriginal reserve.

Kimberley

The Kimberley IMCRA region runs from Cape Leveque to Cape Londonderry (near Kalumburu) and includes the Buccaneer Archipelago. It has a very complex ria shoreline with many islands, and sandstone and dolerite escarpments, and headlands protecting the calm inlets containing turbid waters, muddy banks and large mangrove stands.

Due to high rainfall, large fluvial run-off occurs through the six major rivers and many smaller creeks, creating a stunning display of waterfalls during the wet season.

The tidal range increases up the coast with tidal ranges recorded up to 12 metres. This coastline is renowned for spectacular scenery and iconic areas of Montgomery Reef, Horizon Falls, King George Falls and Buccaneer Archipelago. The coastal tenure in this region includes a mix of Aboriginal reserves, nature reserves and Department of Defence reserve.

King Sound

The King Sound IMCRA region includes the waters south of Point Osborne and Shenton Bluff and the Fitzroy River, Doctor's Creek (near Derby) and Strokes Bay. It has large tidal ranges, low wave action and turbid sediment laden waters. The Port of Derby has the second highest tidal range for a port in the southern hemisphere at 10.8 metres.

Water quality is heavily influenced by wet season flows from the Fitzroy River, which dominates the Sound's catchments. The coastal tenure is a mixture of Aboriginal reserves and pastoral leases.

Canning

This region features rocky headlands, wide bays and "V" shaped creek systems extending from Cape to Cape Missiessy Leveque, which is located near One Arm Point and includes the Lacepede Islands. Similar to the EMB IMCRA region, this area has little fluvial run-off and medium wave action. The Dampier Peninsula, which is predominantly Aboriginal reserve, falls within this region.

Eighty Mile Beach

The Eighty Mile Beach (EMB) IMCRA region extends from Cape Keraudren to Cape Missiessy (South of Bidyaganga) with coastal areas consisting of almost continuous curving white beaches of siliceous sands and dune systems. The beach is on average 100 metres wide, with a drop-off into extensive tidal

mudflats. Although the region is predominantly white sandy beach, there are a few small bays supporting mudflats and mangrove communities. There is no fluvial run-off and medium wave action is typical in this region. Pastoral leases are adjacent to most of the coastline.

Oceanic Shoals

This is a broad area of submerged and emergent reefs and cays that run along the outer edge of the continental shelf and inshore to the mainland. They extend from the Lyndoch and Troubadour Shoals in the Arafura Sea north of Darwin, to the Rowley Shoals west of Broome.

Evidence from oil exploration core samples indicates that there has been long term subsidence of the continental slope and shelf edge, associated with the collision of the Asian and Australian blocks. To the south-west, the subsidence of the shelf edge has been less dramatic and the Seringapatam, Scott Reef and Rowley Shoals reef systems persist as a disjunctive line of near surface or emergent reefs.

Much of this IMCRA is in Australian waters, with a areas of state waters around islands with land above high water mark, such as Ashmore, Scott, Browse and 2 out of the 3 reef systems of the Rowley shoals.

Pilbara Coast

Pilbara - Nearshore

The Pilbara - nearshore IMCRA region extends from Exmouth Gulf to Cape Keraudren. West of Cape Preston, the coastline falls within the sedimentary Carnarvon Basin with Cainozoic Aeolian and beach rock deposits forming the shore. East of Cape Preston the coastline is near the northern margin of the Pilbara Craton constructed of Archaean metamorphic and igneous rocks. The Archaean rocks, outcrop on the coast at several places, notably in the Dampier Archipelago and a short stretch of the adjacent mainland.

Along the mainland, barrier island and associated protected lagoons, embayments and deltas predominate and the coast is either open or partly protected by chains and clusters of small, nearshore, shelly limestone or ovoid limestone islands (especially in the west). Mangrove and intertidal mudflat communities dominate the Pilbara coastline, with occasional beach and rock platform coastal habitats scattered in between. Several large seasonal river estuaries, associated with extensive mangals and salt marsh flats occur in this region.

The Dampier Archipelago is an inundated land mass now comprising island, rocky reefs and shoals rising from a sublittoral plain. Coral reefs have developed around many of the islands in the Archipelago.

Pilbara - Offshore

This area represents the northern margin of the sedimentary Carnarvon Basin. The continental shelf is wide in this vicinity, with a change of slope at about the 20 metre bathymetric contour. Just inside this contour there is a series of limestone islands – South and North Muiron, Sunday Island, Serrurier, Bessieres, Thevenard, Rosily, Barrow and the Montebello Islands. The islands are built of Pleistocene or Tertiary limestone, usually with Holocene sand cays accreted to them.

Fringing coral reefs are well developed on the seaward sides of most of these islands. The seaward sides of the Muiron and Barrow Islands have intertidal rock platforms, a habitat not represented in the Pilbara Inshore area. Wide intertidal sand flats occur on the leeward sides of most of the islands, often with the sand forming thin sheets over a rock pavement.

North West Shelf (NWS)

This region extends from offshore in the Pilbara, northwest into the Kimberley. The southern portion of the NWS is a wide continental platform bordered by the Australian continent on one side and by an

abyssal plain on the other. Sediments are predominantly calcareous with little sediment currently being supplied to this region.

Gascoyne Coast

Ningaloo (see Pilbara for Exmouth Gulf Geomorphology)

The coastline of the Ningaloo region is a high-moderate energy coastline with a fringing reef system protecting the coast from severe wave action. The climate is semi-arid with seasonal storms and creeks, with a maximum high tide of 1.7 metres. The Leeuwin current passes close to the reef thereby having strong influence over the biota in these ecosystems.

The geomorphology of this region is largely made up of Tertiary sedimentary rock and Quaternary limestone from the Carnarvon Basin. The coastline varies from a very hilly steep relief in the north to low relief in the south. In the north, the Range occurs within close proximity to the shore with a high hinterland and narrow coastal plain consisting of Holocene dunes. The shoreline varies rapidly from sandy beaches to rocky shores revealing underlying limestone. There are several locations where sand spits have formed semi-protected bays with sandy beaches comprised of carbonate sands.

Shark Bay

The Shark Bay IMCRA Region includes the shallow embayments of Shark Bay World Heritage Area and includes the Bernier and Dorre Islands. The climate of the Shark Bay region is arid-semi arid with seasonal rivers and creeks forming deltas on the eastern side of the mainland. Water is oceanic at the open end of the bay but becomes meta-saline to hypersaline in the upper reaches of the inlets. The maximum tidal range is 1.2 metres with low to moderate wave action

Shark Bay is predominantly a shallow embayment, protected by offshore Pleistocene limestones formed from inundation of the coastal plain. The bay opens to the north and consists of slender internal peninsulas dividing the southern sections of the bay into two main long north-south facing inlets. There is a build up of sediment in the bay forming a series of banks and sills. Of extreme importance is Faure Sill, which shields the entrance to Hamelin Pool and is responsible for the hypersaline conditions of Hamelin Pool, which support globally significant stromatolite communities.

The seabed and coastlines consist of calcareous sands with extensive seagrass development forming some of the richest and largest seagrass communities in the world.

Zuytdorp

The Zuytdorp region includes the coast from Gnaraloo Bay to the northern coast of Shark Bay, the outer waters of Shark Bay and a rugged high energy arid to semi-arid cliff dominated coastline to the south of the Shark Bay. Due to heavy swell and severe wave action high energy coasts, cliff faces and inter-tidal rock platforms are exposed.

The Quobba Coast and Gnaraloo consist of Pleistocene cliffs in the south and Miocene cliffs in the north with a low undulating hinterland. The northern cliffs are high and accompanied by narrow inter-tidal rock platforms widening to the south as cliffs become lower. The Zuytdorp region includes waters around Bernier, Dorre and Dirk Hartog Islands (which are included in the Shark Bay World Heritage Area), in addition to the Edel Land Peninsula and extends south to almost Kalbarri.

Nullarbor Coast

All waters of the Nullarbor coast fall within the Eucla IMCRA region. This area is representative of semi-arid climate with hot dry summers and cool moist winters. Water temperature varies from 14 degrees Celsius in winter to up to 22 degrees Celsius in summer depending on the influence of the Leeuwin Current.

The region has a small tidal range between 0.8 to 1.2 metres with high to moderate wave action. Key components of the coastal, terrestrial geomorphology are the extensive Nullarbor karst system of the Eucla Basin within the sedimentary limestone deposits, which is one of the largest in the world.

Major feature of the Nullarbor coast include:

- **Cape Arid National Park, Nuytsland Nature Reserve/ Israelite Plain** – Large areas of shallow coastal wetlands and saltlakes, backed by Mount Ragged and the Russell Range in the West, and the low escarpment ridge of the Wylie Scarp in the east, unique coastal star sand dunes and Eyre Bird Observatory.
- **Point Culver and Twilight Cove** – Transition to sheer coastal limestone cliffs, the Baxter Cliffs (60-90m high). This stretch of coast consists of rocky cliffs with narrow rocky platforms present at the base of cliffs.
- **Eucla Basin** – Homogenous, shallow basin lined with clay soils over limestone, backed by the Hampton Range. Very low drainage ridge and corridor features, no defined river courses, no estuaries. Intermittent areas of coastal vegetated and unvegetated unconsolidated coastal sand dunes. Low energy sandy bays, with shallow offshore gradients, and extensive limestone reefs.

2.8.3 Major Use and Value of Coasts

Coastal Living

There is limited coastal development in the Kimberley due to its low population base and lack of heavy industry. Towns along the Kimberley coast are Broome, Derby and Wyndham, as well as several large Aboriginal communities and many smaller outcamps. The town with the fastest growth rate is Broome, which has doubled its population during the last 10 years, to approximately 14,000 people and there are concerns about impacts of the construction of new suburbs and increased population as well as increases in commercial activity.

Major coastal towns of the Pilbara include Dampier, Karratha, Onslow and Port Hedland. Industry is the major driving force behind development in the Pilbara, with major stakeholders in the mining, fisheries and aquaculture sectors. The mining industry has lead strongly in developing port facilities in the sub-region, as a very important part of the Pilbara's export potential.

The four main townships in the Gascoyne are all located on the coast – Exmouth, Coral Bay, Carnarvon and Shark Bay. Carnarvon is the largest town and is an important regional centre (Western Australian Planning Commission, 2004). The population of Carnarvon represents 83 percent of the total population of the Shire of Carnarvon. Exmouth is the second largest townsite in the Gascoyne and at present the current population of Exmouth represents 78 percent of the Shire of Exmouth. Coral Bay is an important tourism settlement however, it has limited health and no educational services (Western Australian Planning Commission, 2004).

The Nullarbor/ Eucla coastline is very sparsely populated, where townships are concentrated along the Eyre Highway, some 30 to 40 kilometrs inland from the coast. Coastal settlements include squatter shack development for weekend houses and commercial fishermen at Red Rocks, Wanteen, and Eucla.

Although the population is sparse along the Rangelands coast, most coastal settlements have community groups involved with coastal management and on-ground actions. An example of this is the Cape Conservation Group, which initiated the Ningaloo Community Turtle Monitoring Program. The Program is now being considered as a model for communities in the Pilbara and Kimberley to follow, and Environs Kimberley involvement in Eighty Mile Beach monitoring.

Indigenous Use, Value and Heritage

There is a wealth of Aboriginal history in the Region, possessing strong cultural heritage including Aboriginal occupation and maritime heritage. For groups that traditionally lived along the coasts and

relied on its resources for survival, the coastal geographic features, and the plants and animals that live there, have important spiritual connections for them. Due to the large expanse of the Region's coastline, there are many Aboriginal communities and language groups that have a close connection with the coasts and a diversity of cultural and spiritual values.

The coast has important connections to about 18 different language groups in the Kimberley that traditionally lived along the coast. Many of these groups still live in or near their traditional lands and rely on coastal and marine resources for their sustenance and spiritual connection. Many areas of the Kimberley also have lands of predominately Aboriginal tenure bordering the coast, such as the Dampier Peninsula and North Kimberley. In the former case there are many groups that live in communities on their lands, whilst in the North Kimberley many people are isolated from their family lands due to logistics of living in the remote region and circumstances of history. Despite this disconnection the people of this sub-region still have strong feelings to their country and have desires to reconnect with their homelands. There is a close held belief in Aboriginal people that country is not healthy without people to look after it.

There are many significant sites along the Pilbara coastline, with both European and Indigenous cultural value. The Burrup Peninsula is reputedly the location of the world's most extensive and diverse assemblage of rock engravings (petroglyphs). Local Indigenous groups have a deep appreciation of the Burrup Peninsula, as there are many important and sacred places that appeared in the landscape in creation times, "*when the world was soft*" (CALM, 2003). As well as the high social values of these sites along the Pilbara coast, nationally and internation cultural heritage sites generate significant economic activity. In the Pilbara Aboriginal people have close connections to the desert and marine environment. This area is known as a place "w*here the desert people may also be known as the saltwater people".*

In the Gascoyne, records of Aboriginal occupation in Shark Bay date back 22,000 years to when most of the area was dry. Rising sea levels flooded Shark Bay 6,000 to 8,000 years ago leaving remnants of Aboriginal habitation in many areas in particular Dirk Hartog Island and Peron Peninsula. In North West Cape, Aboriginal habitation was thought to have occurred at least 32,000 years ago (Western Australian Planning Commission, 2004).

In the Gascoyne, the Gnulli Working Group is involved in progressing the Gnulli Native Title claim. Gnulli means "*All of Us*" and the claim group includes Traditional Owners of Exmouth Gulf and surrounding areas (Western Australian Planning Commission, 2004). Language groups within the claim include Jinigudira/ Thalanji and Baiyungu language groups. The Gnulli are recognised as the custodians of the land and sea and Aboriginal culture in the Exmouth and Ningaloo region. The foreshores of northwest cape contain burial grounds, middens and fish traps and present an early history of Aboriginal inhabitants of the northern Gascoyne coast.

Some of the major management issues for Aboriginal heritage include ensuring that cultural sites are not adversely impacted by human activity and ensuring that Aboriginal communities have access to hunting for traditional food sources. Key management strategies include the integration of Aboriginal land management with modern day management approaches to natural resources, capturing and recording traditional knowledge, increasing general community knowledge and appreciation for Aboriginal heritage, and acknowledgment of Traditional Ownership of the lands and waters.

Recreation and Tourism

One of the constants of the Rangelands coast is the availability of near pristine and remote wilderness areas that provide the perfect blend for nature-based tourism and recreational activities. The Region itself, being the largest NRM region in the country, provides a plethora of tourism and recreational activities. These range from passive activities such as kayaking, diving, surfing, snorkelling, camping and marine life observation to more active tourism and recreational opportunities such as fishing, spear-fishing, game fishing and mortorised boating. There are very high participation rates in coastal based recreational activities by locals. It is imperative that all activities are adequately managed so that these coastlines can be appreciated in years to come.

Each sub-region has its own specific draw cards which, when combined can provide some of the most exciting and diverse, nature-based coastal tourism opportunities in the world.

The Kimberley attracts thousands of people worldwide to its amazing geological formations and freshwater systems that carve out gorges and create some of most spectacular coastal seaside scenes in the world. The remoteness of the area, combined with its wilderness values provides prime opportunities for scenic coastal flights and cruises. Coastal four-wheel driving and camping are popular activities however, water-based activities such as diving, skiing and surfing are restricted to the most heavily visited and accessible areas near Broome. This area is well recognised for its quality tourism products with many attractions and businesses winning tourism awards for example Broome's Cable Beach has been voted Western Australia's best beach in 2004 and 2005.

Similarly, the Pilbara provides significant tourism opportunities with some of the most iconic holiday experiences in Western Australia (Western Australian Tourism Commission, 2004). There is a high level of coastal island activities, such as camping, 4WD, rock climbing, fishing, turtle and whale watching, walking and shell collecting. These high levels of human use are generally localised in areas of predominantly sandflats, beaches and dune areas along the Pilbara coastline and islands (eg Cleaverville Beach, Ashburton rivermouth). Marine-based activities found throughout the Pilbara include diving, snorkelling, swimming, sailing, boating and various other watersports (eg skiing, jetskiing).

The Pilbara coast, which includes more than 250 relatively pristine islands, is highly significant for its natural heritage and internationally recognised Aboriginal sites. CALM manages 19 island Nature Reserves, which effectively covers just over 50 percent of the islands in the Pilbara (Pilbara Development Commission, 1995). Visitation of the islands, by both locals and tourists, is relatively high particularly during the cooler months of the year (April – September).

The Gascoyne Region is important for nature-based tourism activities (Wood and Dowling, 2002). The annual estimated visitation to the region is 260,000 generating approximately $141 million (Western Australian Tourism Commission, 2002). The major draw cards to the Gascoyne include recreational fishing, boating, diving, camping and wildlife interactions. Wildlife interactions tours are largely provided from key points of Exmouth, Coral Bay and Monkey Mia. These include Monkey Mia dolphin interaction program, whale shark experience, dugong observation, and marine turtle nesting process observation opportunities which are regulated by CALM.

From the Exmouth Gulf to the remote embayments of Shark Bay and the treacherous cliffs of the Zuytdorp Bioregion, there are a variety of different wilderness experiences that are greatly valued. Specific areas of value for tourism include the Shark Bay and Ningaloo Marine Parks and the Ningaloo Coast, coastal National Parks such as, Shell Beach, Francois Peron and Cape Range, and off-shore islands (reserves) such as Murion. The main townships for tourist accommodation are Exmouth, Coral Bay, Carnarvon, Denham and Monkey Mia, and in between are pastoral stations providing camping facilities including Ningaloo, Woroora, Quobba and Gnaraloo.

Large areas of the Southern Nullarbor coast fall within Nuytlands Nature Reserves, and due to remoteness and difficulty of access, accessible coastal locations have very localised visitor pressures. The UCL east of Nuytsland Nature Reserve to Eucla has a small number of coastal sites used by weekenders and fisherman, where squatter settlements have developed at Red Rocks, Berry Bush Lagoon and Wanteen. Accessible tourist attractions of the old telegraph station and jetty at Eucla are visited more regularly.

Mining and Petroleum, and other Industries

The coastal areas of the Kimberley have a number small scale mining and industrial developments. The major mining venture at present is the extraction of iron ore from the Cockatoo and Koolan Islands. Because the pit operations are adjacent to the shore line and are below sea level, there is the potential to impact on the marine environment. The companies operate under strict environmental approvals to minise the risk of environmental impacts on surrounding areas.

There are large reserves of oil and gas off the Kimberley coast and there are plans to produce natural gas and condensate from the Browse and Bonaparte Basins. Areas of the coast may be needed for processing plants and support infrastructure.

The ports of the Kimberley handled 785229 tonnes in 2001/ 2002, with Wydhnam being able to handle ships up to 26,000 tonnes, Derby 15,000 tonnes and Broome 28,000 tonnes (source KDC). The volume through the Broome port has significantly increased during the last 10 years and it is extending the jetty in 2005 to double its berthing capacity.

The Pilbara is world renown for its mineral, oil and gas resources. Its resource leadership was established in the late 1960s with the development of coastal mining towns including Karratha, Wickham and Port Hedland. The resource export trade of the Pilbara ports (Dampier, Cape Lambert, and Port Hedland) was valued at $16 billion in 2002/ 2003.

There are three major ports in the Pilbara: Dampier, Port Walcott (Cape Lambert) and Port Hedland. Dampier Port is controlled by the Dampier Port Authority and is suitable for general cargo vessels up to 35,000 tonnes or from 15,000 - 320,000 dead weight tonnes (DWT). Pilbara Iron, Woodside Offshore Petroleum and Dampier Salt own and operate private wharves within the port. Port Walcott, located at Cape Lambert, is a private facility that stretches approximately 2,800 metres to sea, and is capable of handling ships of up to 320,000 DWT. Port Hedland contains four major wharves, two of which are controlled by the Port Hedland Port Authority and the remaining two are owned and operated by BHP Billiton. The wharves can accommodate bulk carriers of 170,000 – 260,000 DWT (Pilbara Regional Transport Strategy, 1997).

In the 1980s, production began from several other fields off the Pilbara coast and production has increased dramatically in the last few years. Petroleum companies have developed oil-loading facilities at Barrow Island, Varanus Island and Thevernard Island. Gas from the North West Shelf Joint Venture is piped ashore to be converted to LNG on the Burrup Peninsula, and then along the Dampier to Bunbury pipeline for domestic consumption. Barrow Island is the preferred option for production of LNG from the giant Gorgon gas field. Onslow also provides services to offshore petroleum projects, which is a huge economic benefit for the coastal settlement (Pilbara Regional Transport Strategy, 1997).

The Burrup Peninsula, in particular is an area that has attracted interest in the past and more recently as an area for industrial development due to the close proximity to the Dampier Port facilities. Developments proceed under strict guidelines and after extensive consultation due to the high ecological and cultural values of the area. Currently the area is one of the few locations in the Rangelands where there is value-adding or manufacturing of raw products, with the Woodside LNG plant and the Burrup fertilizer plant.

The Dampier salt field was established in 1968, and is now the largest exporter of salt (sodium chloride) in Western Australia. Operations now exist at the historical Dampier field, plus operations at Port Hedland, Dampier and Cape Cuvier near Carnarvon. Production capacity is around four million tonnes per year, most of which is exported to South and East Asia (Dampier Salt, 2000). Other salt ventures include the Shark Bay Joint Salt Venture, which operates in Useless Loop, Shark Bay and Onslow, and there are further proposals by Straits Resources to mine in the eastern areas of Exmouth Gulf

The Gascoyne also has potential for further mineral and petroleum expansion. For example, areas surrounding and adjacent to the Muiron Islands have been earmarked for future petroleum and mineral exploration and development.

There are a number of boating facilities in the Gascoyne, but no major ports in the nearshore coastal waters. The main boating facilities are located at Exmouth and Carnarvon with smaller facilities provided in Denham, Monkey Mia and Coral Bay.

There are no major commercial industries, mining industries or jetty facilities on the Southern Nullarbor coastline. Local commercial and recreational fishermen launch small crayfish and wet line fishing boats directly from the sandy beaches. The area's deeper coastal waters are accessed from remote ports of Ceduna and Esperance.

Conservation

The coast provides important habitat for both land and sea based fauna such as breeding grounds for birds and turtles. Coastal flora is often particularly specialised for the extreme environmental conditions experienced along the coast and is often restricted in its distribution specifically to coastal areas. The flora of the coasts also provides protection of the coastal ecosystems and provides an important buffer to natural processes such as cyclones and tsunamis.

This coastal value is covered further in the marine and terrestrial biodiversity sections.

Pastoralism

Pastoralism is a major land use adjacent to much of the Rangelands coast. The coastal areas support differing types of pastoral activities including cattle, sheep and goats. However, some pastoralists have diversified their businesses to include nature-based tourism through provision of camping sites and facilities on pastoral leases at coastal locations, particularly on the Gascoyne coast.

Coastal pastoralism and diversification into other operations such as tourism must be managed with an integrated approach with other resource uses such as recreational fishing. These matters are being considered through a number of State Government policies and strategies.

2.8.4 Major Threats to Coasts

Unsustainable Tourism and Recreation

Tourism and recreational activities adversely impact on the marine and coastal assets to varying degrees, depending mainly on access to areas and population pressures. Issues contributing to unsustainable tourism include lack of signage and formalised camp sites, and the difficulties of managing agencies providing effective enforcement and regulation of remote coastal areas.

Unmanaged and uncontrolled recreational camping and access by off road vehicles can cause dune degradation, loss of aesthetic value and increased erosion from exposure to environmental conditions. Other adverse impacts from tourism and recreation include litter, trampling of sensitive inter-tidal communities, vessel impacts including collision with marine fauna, increased turbidity (eg propeller impacts on seagrass communities), oil spills and the translocation of non-endemic species, coral damage from diving, boating and snorkelling, and loss of habitat for threatened species and migratory species including turtle nesting rookeries and shorebird roosting and feeding grounds. In addition, damage by tourists to significant sites such as caves and the material they can contain is of concern to Traditional Owners.

These impacts on the coastal environment can lead to loss of visitor experience resulting from competition for resources, loss of aesthetics, overcrowding and incompatible recreational and tourism activities; for example high speed boating and snorkelling at the same location.

A large part of the attraction of tourism on the Rangelands coast is the opportunity to explore a relatively pristine area and experience the remote feeling of "wilderness". Over development and excess tourist numbers could threaten visitor experiences and the environment, and must be managed accordingly. This has been recognised as a threat in the Kimberley coastal cruise market, which has experienced rapid growth during the lpst 10 years. The charter industry via the Kimberley Marine Tourism Association, has responded to this threat by developing MOUs about operational procedures within their organisation and with external partners such as the pearling industry.

It is important that tourism in the Region is managed in accordance with tourism planning and management tools such as the Ningaloo Coast Regional Strategy – Carnarvon to Exmouth (Western Australian Planning Commission, 2004) as well as appropriate codes of practice for wildlife interactions, the implementation of protected area management plans and the development and implementation of local government coastal management plans.

Mining and Industry

The mineral and petroleum operations are confined to small areas of land, occupying about half of one percent of the State's area. Heavy industries in the Rangelands are mostly extractive in nature and are responsible for the delivery of large revenue to the State. Also, ports occupy only discrete areas generally located adjacent to deep waters for access.

Mining and industry potentially cause ecological impacts including pollution from effluent, the clearing of native vegetation, and the introduction of invasive species via ship ballast water. Whilst these operations have the potential to impact upon the environment, they operate under strict environmental conditions principally set in the provisions of the *Environmental Protection Act 1986*, *Mining Act 1976* and *Petroleum Act 1967*. In addition, many of the companies have developed their own environmental and sustainability principles and commitments. Such measures however, cannot totally rule out incidents where materials such as petroleum products pollute coastlines causing severe impacts on marine and coastal organisms.

There is also potential threat from the impacts of future development. Currently there is limited heavy industry that value adds to products along the Rangelands coast, thus there are limited discharges of wastes that value-adding industries tend to generate, such as effluent. Proposals such as tidal power plants, transporting of mining products and processing plants could increase impacts from heavy industries.

There are currently limitations in research about potential threats, which is required for strategic planning and the assessment of the cumulative impacts of future developments. The Rangelands coastline and its marine environment are isolated requiring additional research to provide baseline data for assessing possible future threats or developments.

Unsustainable Pastoral Management

Along parts of the Rangelands coast there is a small coastal reserve between pastoral properties and the ocean, but often these boundaries are not fenced allowing uncontrolled grazing of coastal areas. There are also issues relating to access of coastal reserves on pastoral land for recreational activities. Poor management can also adversely affect the coastal environment through weed incursions, inappropriate fire regimes, and the impacts of domestic and non-domestic animals causing significant degradation of mangals, dunes and other coastal environments.

Weeds and Animal Pests

Movement of people, equipment and animals throughout the Rangelands has helped spread a variety of invasive weeds along its coasts and onto island communities. These have a variety of affects on the coasts such as altering fire regimes and displacing native species.

Coastal areas can also be focal points for animal pests such as where foxes and dingoes predate on turtle nests, and animals such as goats and cattle trample and graze delicate dune vegetation.

The island communities are especially prone to the effects of introduced plants and animals, due to their isolated nature. Some islands have introduced predators such as cats and rats that affect animal populations and breeding success. For example, seabirds selectively breed offshore due to lower predation rates and the introduction of a species such as rats can drastically affect fledging rates. To counter these introductions some control work of introduced predators has been done on Pilbara and

Kimberley islands, however further work is required in many areas to reduce the impacts of introduced species on the island communities.

Other examples of introductions to islands include the common house mouse (*Mus musculus*) on Dixon and Varanus Islands, and buffel grass (*Cenchrus ciliaris*) and kapok bush (*Aerva javanica*) in the Dampier Archipelago. Examples of successful eradication programs include both the rat (*Ratus ratus*) and the cat (*Felis catus*) populations on the Montebello Islands.

There is a potentially large threat from new introductions, especially in the Kimberley due to its proximity to neighbouring countries and interstate waters.

Furthmore, and compounding any current or future threats is the diffculaty associated with detecting and manaing outbreaks over such a large, inaccessible area.

Inappropriate Coastal Development

Coastal development can have detrimental impacts on the coastal ecology of an area. Key risks and threats associated with coastal development include loss of habitat for significant species such as migratory birds or marine turtles, coastal dune erosion, loss of coastal vegetation integrity, sewage and pollution caused from unmanaged human wastes, pollution from boating, and an overall loss of aesthetics for residents and tourists living in or visiting an area.

To manage the threat of inappropriate coastal development a suite of coastal management tools should be developed for the coastline. Key management priorities include the development of coastal management tools for areas of the Rangelands that currently lack formal management and planning. This will require the joint efforts of State Government, local government, resource use groups and local communities. Planning should address:

- cumulative impacts of developments on habitat;
- opportunities for collaborative planning and sharing infrastructure to minimise environmental footprint;
- lack of research into marine and coastal ecosystem inventory and function; and
- Aboriginal engagement site recognition and management.

Climate Change

The effects of climate change on the coastal areas of the Rangelands are relatively unkown. Melting polar ice-caps, and the resultant addition of large amounts of fresh water to the ocean, will impact the circulation of currents and in turn have effects on regional climate patterns, plus physically lead to rising sea levels. These effects may have specific regional impacts, such as changing cyclonic activity and inundation of low-lying areas, such as coastal floodplains. This may have substantial economic, social, and environmental consequences, and hence there is a need to do further work to assess the possible impacts on the marine and coastal areas of the Rangelands.

Loss of Cultural and Spiritual Values

During the past 200 years, European settlement has seen significant demise of Aboriginal culture. European settlement saw the introduction of diseases that claimed the lives of many Aboriginal people whilst large numbers were taken to quarantine on islands such as Bernier and Dorrie Island never to see their traditional lands again. As a consequence the Traditional Owners of the land and sea had their lifestyles interrupted by movement to nearby towns and pastoral stations for work.

Over the years there have been many attempts to restore and reinstate Aboriginal cultural heritage and there is still a long way to go. Many sites continue to be degraded by un-managed access, lack of awareness, and a lack of respect of Aboriginal cultures and values. As the majority of Aboriginal values

are centred on the natural environment, their cultures and belief systems are recognised and contribute to NRM in the Rangelands.

2.8.5 Current Management of Coasts

Management Bodies

NRM along the Rangelands' coast varies greatly. Below is a summary of key management bodies that are relevant to coastal and marine NRM in the region, accompanied by examples of existing management tools.

- CALM manages Marine Conservation Reserves vested in MPRA (including management plans and education and monitoring programs) and manages terrestrial/ coastal estates (UCL, conservation reserves and parks).
- Department of Fisheries manages and regulates commercial and recreational fishing, aquaculture and pearling and has a lead role in enforcement of fisheries legislation within state and federal waters.
- Environmental Protection Authority assesses reports and makes recommendations on proposals that may significantly affect the coastal and marine environment.
- Department of Environment assists the Environmental Protection Authority in the process of assessing proposals that may significantly affect the marine and coastal environment and administers pollution control legislation.
- Department of Industry and Resources administers legislation that controls mineral and petroleum exploration and development and regulates the petroleum industry operations.
- Port authorities have tenure over localised coastal areas, within which they manage the natural resources of the area.
- Department for Planning and Infrastructure is responsible for coastal and marine planning in Western Australia, as well as administration of pastoral lands
- Local government also play a significant role in managing coastal areas. In the Rangelands these are the Shires of Broome, Derby/ West Kimberley, Wyndham/East Kimberley, East Pilbara, Port Hedland, Roebourne, Ashburton, Exmouth, Carnarvon, Shark Bay, and Dundas.

CALM, local government and the Department for Planning and Infrastructure are primarily responsible for planning and management of coastal areas. In some cases, CALM has joint management agreements with local government authorities, such as where CALM and the Exmouth Shire jointly manage the Jurabi Coastal Park on North West Cape.

The level of local government involvement in coastal management is variable between shires. Some shires currently have a low capacity for coastal management work beyond town limits, whilst others are actively involved in groups such as the South Coast Management Group comprising members from local government, local NRM groups and the community. Such activities by shires can be supported by the Coastal Planning Program, which aids local governments to develop plans and capacity for managing coastal areas (Western Australian Planning Commission, 2004).

An example of coastal planning strategy involving various groups is the Ningaloo Coast Regional Strategy that covers Carnarvon to Exmouth. This is a 30 year plan that is used to strategically establish a framework for sustainable tourism and land use on the Ningaloo Coast. The strategy consists of eleven guiding principles, covering areas of sustainable development, community aspirations, Aboriginal heritage, limits of acceptable change, precautionary principle, cumulative impacts, protection of high conservation values, protection of remoteness values and the protection of biodiversity (Western Australian Planning Commission, 2004). The Strategy is currently being implemented by the Ningaloo Sustainable Development Office (NSDO).

Further planning strategies, tools and plans that have implications for coastal and marine management in the Rangelands are listed at Appendix IV.

Indigenous Coastal Management

There are good examples of Indigenous engagement in coastal management in the Rangelands, which have been used as case studies extensively thoughout Australia. For example, the Saltwater Country project in the Kimberley. This project is intended to conserve traditional knowledge pertaining to the use and future management of the Kimberley coastline from the Buccaneer Archipelago (north of Derby) to Kalumburu. The project (and its associated final document) will significantly assist the Traditional Owners of the Kimberley coast in expressing their natural and cultural resource management planning aspirations and concerns to the wider community and NRM processes in the Kimberley. Another Kimberley based example is at Minyirr Park, Broome, where Rubibi and the Shire of Broome have had a close working relationship for the past 10 years in managing the coastal reserves of Cable Beach.

In the Pilbara, there are issues regarding the security of tenure of some coastal areas, and changing tenure of some islands and island systems. An example of an area that is currently undergoing a consultation period to develop a joint management plan is a conservation reserve on the Burrup Peninsula with CALM and local Indigenous groups.

2.8.6 Coastal RCTs and MATs

RCT16: Maintain and improve condition of priority terrestrial coastal, and all island habitats in the Rangelands, as measured at representative sites by 2020, with a quantified target set by 2006

Management Action Targets		Geographic Focus	Management Actions	Potential Partner Groups	Links to RCTs	Priority
Benchmarking and Monitoring						
12 	**S1.** By 2008, the region's coast and coastal water values and associated threatening processes have been identified, characterised and prioritised for the Rangelands	Regional	• Set quantified targets for condition for priority terrestrial coastal and island habitats in the rangelands by 2006 • Assess and characterise values for Rangelands estuarine, marine and coastal areas" • "Prioritise values and threats by 2006" • "Establish benchmarks for priority values and threats by 2006"" • Marine habitats are mapped using remote sensing, ground truthing and other GIS techniques	State government Industry groups Community groups Land managers RCG Traditional Owners	RCT16 RCT17	1A
11 	**S2.** By 2006 establish baseline datasets and subsequent monitoring programs sufficient to measure the impact of nature-based tourism on the coastal areas of the Rangelands	Priority areas	• Establish benchmarks and indicators for the environmental performance of nature-based tourism industries • Conduct biodiversity inventories in priority marine and coastal ecosystems, habitats and species to be determine by 2006 • Monitor visitor experience and expectation • Monitor and manage waste production of nature-based tourism • Established and maintained easily accessible data base • Collect recreational fishing baseline datasets for priority species and in priority areas by 2007 • Continue to improve data collection for fisheries and marine ecosystems where needed and appropriate to size, risk and needs of the fisheries	State Industry Community Traditional Owners Research NGOs	RCT16 RCT17 RCT1	1B

Management Action Targets		Geographic Focus	Management Actions	Potential Partner Groups	Links to RCTs	Priority
11 	**S3.** By 2010, the impact of climate variations on the NRM assets of the Rangelands Coast will be well understood with predictive models available for fisheries, coastal and tourism management	Regional	• Develop/adopt models to predict changes in climate • Make modelling outcomes available for planning and educational purposes	State Industry Community Traditional Owners Research NGOs	RCT16 RCT17	1C
On-ground Actions						
11 	**S4.** By 2006 support implementation of 3 recreation and tourism management frameworks.	State Priority areas	• Implement a planning framework for sustainable tourism development consistent with current strategies and tourism management plans • Implement educational programs for tourism operators (including ecosystem values) through including the involvement of local and state government and community • Plan for measures to control and direct coastal access in priority areas • Improve signage and interpretation facilities at key tourist locations and access points • Encourage tourism operators to educate tourists about NRM with a focus on valuing and protecting the of the Rangelands coasts • Conserve areas of "wilderness" value through appropriate planning and management • Develop site specific monitoring programs at priority tourism valued areas • Develop guidelines for appropriate tourism development at priority sites across the rangelands • Develop wildlife tourism management frameworks to ensure that all wildlife interactions are adequately managed and monitored by 2010. • Support t he implementation of the Ningaloo Coast Regional Strategy and support t he development of similar regional strategies throughout other priority areas of the Rangelands Coast • Develop coastal access management plans for coastal areas in consultation with Traditional Owners • Develop adequate access networks and close inappropriate access points and provide necessary signage and infrastructure (eg waste disposal units)	State Industry Community Traditional Owners Research NGOs	RCT1 RCT16	1A

Management Action Targets		Geographic Focus	Management Actions	Potential Partner Groups	Links to RCTs	Priority
12 	**S5.** By 2010 develop and commence the implementation of integrated coastal management plans that foster the principles of ecologically sustainable development and aim to protect 6 areas of ecological importance	Regional	• Projects in coastal areas area implemented to control access, manage recreation and conduct rehabilitation and education programs in priority areas • Feasibility studies are undertaken for potential coastal development • All coastal and island developments are undertaken within the principles of ESD and are consistent with appropriate coastal development plans and/or strategies by 2004 onwards • Waste disposal and management facilities are constructed at all highly used areas in particular, moorings, boat ramps, marinas, jetties • Adopt proposed access policy from DOLA Access committee for Pastoral Lands as appropriate • Establish consistent principles for coastal planning throughout the region • Support the development of coastal management plans for the region and/or key visitor sites • Develop an environmental audit of coastal development impacts on landforms and biodiversity • Develop partnerships with stakeholders to establish a collaborative framework for managing tourism on the coast (e.g. camping, access, waste management) • Assessment of new developments to consider cumulative impacts of developments on natural resources in the area	State Industry Community Traditional Owners Research NGOs Industry community	RCT1 RCT16 RCT17	1A
12 	**S6.** By 2005, all aquaculture developments are consistent with the guidelines and recommendations in aquaculture development strategies and plans for the region and adequate monitoring and evaluation of the industry is undertaken	Site specific	• Monitor and evaluate the impacts of aquaculture on biodiversity and water quality • Best management practices and Environmental Management Systems are widely adopted • Develop and implement Environmental Management Systems for aquaculture developments • Encourage innovative approaches to improve the sustainability of the aquaculture industry • Revise aquaculture development plans and guidelines in light of new developments in the industry • Implement aquaculture development plans and guidelines consistent with ecosystem based management and ecological sustainability principles • investigate projects that foster collaboration with other industries such as horticulturalists	State Industry Community Traditional Owners Research NGOs	RCT16 RCT17 RCT19 RCT1	1B

Management Action Targets		Geographic Focus	Management Actions	Potential Partner Groups	Links to RCTs	Priority
Institutional Frameworks, Planning and Policy						
12 	**S7.** Environmental Management Programs for all port areas and boat harbours are developed and adopted by 2008	Regional	• All ports to develop and adopt environmental management systems and environmental management programs taking into account waste management, pest and disease and impacts during operation e.g. dredging • Prioritise boat harbours for EMPs	State Industry Community Traditional Owners Research NGOs	RCT16 RCT17 RCT1	1B
Education, Awareness and Future Engagement						
11 	**S8.** Implement an educational program focused on the sustainable use of coastal environments and coastal and marine biodiversity targeting user groups and other key stakeholders by 2008	Regional	• Water quality issues associated with rubbish, storm water, sediment, nutrient runoff and changes to water cycle are assessed in consultation with all local stakeholders • Implement a community training and educational program with a focus on marine and coastal community monitoring • Apply necessary management, education and enforcement of fish habitat protection areas, marine parks and marine protected areas • Develop education and awareness programs for cultural heritage recognition and conservation • Support existing education programs implementing educational material based on communication strategy • Undertake education programs for all management regimes, including newly identified MPAs and adequate public consultation • Develop coastal maps showing prohibited areas, access areas and user responsibilities • Develop a communication and education strategy to determine key target audiences, key messages and the best method of educational delivery • Ensure there are strong linkages between all coastal and marine educational programs in the Rangelands Region • Train Aboriginal people in sites recognition and site management • Encourage programs that aim to build capacity of Traditional Owners to live on country and care of country • Develop programs that allow non-Indigenous communities to understand and value the cultural and spiritual values of the coast	State Industry Community Traditional Owners Research NGOs	RCT1 RCT16 RCT17 RCT18 RCT19	1B

Management Action Targets		Geographic Focus	Management Actions	Potential Partner Groups	Links to RCTs	Priority
11 	**S9.** By 2010 80% of nature-based tourism operators are operating within the accepted principles of accredited eco-tourism	Priority Areas State	• Broker tourism packages and incentives for tourism operators • Educate the community, tourists and operators about the principles of eco-tourism and encourage the uptake of eco-tourism activities • Regular auditing of eco-tourism operators	State Industry Community Traditional Owners Research NGOs	RCT16 RCT17 RCT18 RCT19 RCT1	1A
	See MAT L17					
Cultural Heritage						
13a 	**S10.** By 2010 20 culturally significant sites to be protected and/or restored where degradation has occurred	Site specific Priority areas	• Identify culturally significant sites in consultation with Traditional Owners • Encourage projects to protect and restore sites of significant cultural value • Improve protection for heritage sites	State Industry Community Traditional Owners Research NGOs	RCT1 RCT2 RCT16 RCT17 RCT18 RCT19	2A
13a 	**S11.** Investigate the feasibility of establishing community cultural centres in two locations on the coast by 2007	Regional	• Centres include cultural knowledge, biodiversity values, language, art, awareness raising and heritage protection eg. Manbana Aquaculture Hatchery and Discovery Centre, Broome	State Industry Community Traditional Owners Research NGOs	RCT1 RCT2 RCT16 RCT17 RCT18 RCT19	2C
	See MATs L18, L19 L21					

2.8.7 Marine Waters

The Rangelands' marine waters area cover from the high tide mark to three nautical miles off-shore (ie State waters) as well as off-shore islands and for three nautical miles surrounding them. Marine biodiversity assets, in the context of this strategy, relate to organisms that either permenently or periodically inhabit marine waters and associated environments. Such areas include marine waters, coral and other reef platforms, tidal and littoral zones of coastal areas and islands and vegetation communities existing in intertidal areas.

Marine plants communities include mangroves, seagrasses and macroalgal assemblages. Marine animals include, but are not restricted to, invertebrates/crustaceans, molluscs, soft and hard corals, marine reptiles (eg turtles, seasnakes), fishes, marine mammals (eg dolphins, dugongs and whales) and seabirds. The diversity of marine organisms and habitats in the Region's marine environment is immense considering that it is inclusive of more than 75 percent of Western Australia's coastline ranging from the tropical waters of the northern Kimberley to the temperate waters adjacent to the Nullarbor Plain.

A unique feature of the coastal waters of Western Australia influencing marine biodiversity is the presence of a poleward, shelf-edge flow of tropical water that flows down the Western Australian coastline known as the Leeuwin Current. Although the Leeuwin Current flows all year around, it is stronger and closer to shore during the autumn and winter months. The current has major influences on the biogeography of Western Australian marine flora and fauna resulting in the occurrence of tropical and sub-tropical species at lower latitudes than would be expected in other marine waters of similar latitude on the west coasts of other southern hemisphere continents.

Given the diverse nature of marine biodiversity and the natural resources it represents Australia wide it has been nationally (and internationally) recognised that there is a need to ensure its longterm protection and conservation. Since the early 1990s the Australian Governement, States and Territories have been working towards a regional planning framework. This has led to the development of the Interim Marine and Coastal Regionalisation of Australia using a range of information on physical and biological attributes coupled with expert knowledge. The IMCRA regions follow a similar philosophy as the IBRA bioregional classification used in terrestrial environments to provide a structure for planning at a regional scale which is continullay being improved when new data becomes available.

At a more localised level there are a number of key components that comprise marine biodiversity. These components have been used as the basis for the development of conservation management plans in marine areas (and are referred to as Key Ecological Values within these plans). A broad overview of physical and biological components of marine biodiversity in the Rangelands NRM region is summarised in Table 13.

Table 13: An overview of the physical and biological components of marine biodiversity found in the Rangelands NRM region (note: this list is representative and not a comprehensive list of marine biodiversity components).

Physical	Geomorphology	A complex seabed and island topography consisting of islands, islets, headlands, beaches, mudflats, rocky shores, platforms, subtidal and intertidal reefs, sheltered lagoons, channels, and cliffs.
	Sediment quality	The sediments of the Rangelands NRM region are generally undisturbed and are essential to the maintenance of a healthy ecosystem.
	Water quality	The majority of the waters of the Rangelands NRM region are relatively pristine and are essential to the maintenance of a healthy marine ecosystem.
Biological	Coral reef communities	Undisturbed intertidal and subtidal coral reefs and bommies with a high diversity of hard corals. The internationally recognised marine biodiversity coral reef hotspot consists partially of Ningaloo Reef and the outer islands of Shark Bay
	Mangrove communities	Sixteen species of mangroves are found in the Rangelands NRM region,. Many of the Rangeland NRM region's mangrove communities are considered to be of international significance.
	Macroalgal and seagrass communities	Extensive macroalgal and seagrass communities which are important primary producers and refuge areas for fishes and invertebrates.
	Soft-bottom communities	Extensive sand and silt substrates that support a variety of invertebrate species both in and on the sediments. These support large populations of wader birds on intertidal areas
	Intertidal sand and mudflat communities (including samphire communities)	The intertidal sand and mudflat communities of the Rangelands NRM region are primary producers and have an abundance of invertebrate life, which provides a valuable food source for shorebirds.
	Rocky shore/intertidal reef platform communities	Rocky shores predominate on most of the islands and are a major shoreline habitat of the Rangelands NRM region. They provide habitats for a variety of intertidal organisms, which in turn provide food for shorebirds.
	Marine mammals	Ten species of cetaceans have recorded in the reserve system, with the humpback whale passing through the area during its annual migration. Dugongs populations are present from Shark bay north with some of the largest and most intact populations in the world.
	Reptiles	Loggerhead, green, flatback, hawksbill and leatherback turtles are found in the Rangelands NRM region, with the hawksbill population in Australia being the largest remaining in the Indian Ocean. All species except the leatherback use sandy beaches in the Rangelands NRM region for nesting. Large number of sea snakes species found in the region.
	Birds	Islands within the Rangelands NRM region are nesting areas for 15 species of seabirds. The region also provide important feeding and resting areas for migrating shorebirds as recognised in the CAMBA and JAMBA agreements.
	Fishes	A diverse finfish fauna of over 1000 species contributes significantly to the biodiversity of the Rangelands NRM region, including several species listed as extremely rare
	Invertebrates (excluding corals)	A high diversity and abundance of invertebrate fauna within the proposed reserves is an important food source for a variety of marine animals including migratory birds and fishes.

The values of these key components are of particular importance in the Rangelands including:

- The relatively unaltered nature and marine biodiversity of the Kimberley Coast from the Northern Territory border through to Cape Keraudren;
- Oceanic Shoals IMCRA region containing offshore islands, coral cays and rich assemblages of fish on the edge of the Northern continental shelf extending north from Rowley shoals (west of Broome) to Melville Island in the Northern Territory;
- Eighty Mile Beach and Roebuck Bay for their intertidal benthic habitat and its importance to migratory bird species;
- West Pilbara offshore islands and Monte Bello/ Barrow Islands represent a variety of habitat types for terrestrial and marine flora and fauna; such as Montebello Islands mangrove communities are considered to be globally unique given their occurrence in lagoons of offshore islands;
- Dampier Archipelago and Cape Preston for its rich diversity of terrestrial and marine communities representative of Western Australia's north-west offshore islands, as well as being important habitat and breeding grounds for marine species;
- Exmouth Gulf for its extensive mangal systems and role as a nutrient source supporting the prawn fishery in the gulf as well as its function as a nursery area for prawns and other species;
- Ningaloo Reef is one of Australia's largest reef systems and important in terms of the diversity of marine species it supports including large marine fauna such as the whale shark;
- Shark Bay for its terrestrial refuges and for diversity of marine habitats including seagrass beds supporting large populations of dugong, as well as the occurrence of stromatolites in Hamelin Pool; also notable for its World Heritage Status; and
- The relatively unaltered state of the coast and marine biodiversity bordering the southern Nullarbor.

It is noteworthy that there a number of areas within the Region identified as having a high priority for establishing a marine reserve (Simpson and Bancroft, 1998). These are summarised in Table 14.

Table 14: Priorities for Establishment as Marine Reserves

Conservation Value Vs. Threat	Priority areas for establishment of Marine Reserve
High Conservation Value High Threat	Dampier Archipelago Montebello Islands (established 2004) Barrow Island (established 2004) Exmouth Gulf Roebuck Bay
High Conservation Value Medium Threat	Eighty Mile
High Conservation Value Low Threat	Prince Fredrick Harbour
Medium Conservation Value High Threat	Murion Islands (established 2004)
Medium Conservation Value Medium Threat	Oceanic coral banks and islands Cambridge Gulf Buccaneer Archipelago Cape Preston Robe Surrier Islands Lagrange Bay Bernier, Dorre & Dirk Hartog Islands
Medium Conservation Value Low Threat	Pender bay-Cape Borda Depuch and Cowrie Creek Lacapede Islands Keraudren Londonderry Vansittart Bay Admiralty Gulf St. Georges Basin Montgomery Islands Walcott Inlet/Secure Bay South. Ningaloo MP Red Bluff to Point. Quobba Twilight

2.8.8 Overview of the Sub-regions' Marine Waters and Biodiversity

Kimberley Coast

There is a diverse range of marine habitats along the Kimberley coast from diverse offshore islands and coral cays characteristic of Indo-West Pacific biota, productive intertidal areas, seagrass beds and extensive sponge and marine algal beds. Coastal areas contain large assemblages of mangroves, which have been estimated to be 80 percent of Western Australia's mangrove area (Pedretti and Paling, 2001). The Kimberley has the greatest species diversity and structural complexity of mangroves in the world. This diversity in turn supports a wide range of animal communities (Johnstone, 1990).

Below the mangrove belt there are typically large areas of productive intertidal sand and/or mud habitats that are exposed by the high tidal ranges. This results in a moderately high diversity of near shore fauna (MPRSWG, 1994).

King Sound, its large freshwater inputs, mobile sediments and many mangrove creek systems are a unique asset of the Kimberley. A well studied example is Doctors Creek near Derby which is a type site of a geologic record, but more broadly an area that has been studied extensively from a geologic, geomorphologic and ecologic perspective. Some aspects of its unique biodiversity assets are its unique mangrove communities as they occur in an embayment that represents the extreme end of a spectrum of erosional forms (Semeniuk and EnviroEng, 1997). The other is the presence of the extremely rare

and Critically endangered elasmobranch species of *Glyphis sp.* A (speartooth shark), *Glyphis sp*. C (northern river shark) and *Pristis microdon* (freshwater sawfish) Larson, H.K. (2002).

High water turbidity and large tidal ranges in the Kimberley mean that there are few areas of extensive seagrass beds. However, there is a major seagrass system in the area between Cape Leveque and Sunday Island where seagrass density is similar to the *Posidonia* and *Amphibolis* beds found in the southwest of Western Australia. There are also some large areas of dense seagrass in locations such as Sunday and Tallon Islands, and many areas of less dense beds of Halophila that grow at or just below low tide mark of protected bays. These are thought to be important food sources for dugongs.

These habitats support a variety of marine species. For example, the Kimberley seasonally supports large populations of humpback whales, as the coastline also offers many protected areas that are suitable calving grounds. Also many areas are important habitat for recognised threatened species of turtles.

Kimberley waters contain large areas of sponge beds that are made up of sponges, macroalgae and soft corals on soft sediment bottom. Some of these beds are well known sources of pearl shell, but there has been little formal mapping of the habitats.

Nearshore fringing coral communities vary from sparse and relatively low diversity, in term of coral species, to spectacular and diverse walls that can trap waters on low tide and create mazes of pools for other species to thrive. The offshore islands and cays support a high biodiversity that is typical of Indo-West Pacific Flora.

Migratory birds are of particular importance in the Kimberley marine environment. The Eighty Mile Beach area is the most important area for waders in north-Western Australia. Many species cited in international bilateral agreements such as China Australia Migratory Bird Agreement (CAMBA) and Japanese Australia Migratory Bird Agreement (JAMBA) occurs at this site. These agreements encourage the contracting parties to protect the environments on which migratory birds rely. Around 500,000 birds are counted on the beach during annual summer surveys though there can be large fluctuations from year to year due to seasonal variations.

Also near Eighty Mile Beach, the threatened ecological community of Mandora Marsh contains the most inland mangroves (by up to 40 kilometres) in Western Australia, as well as unique plant assembladges and seasonal bird aggregations associated with the springs.

Roebuck Bay, adjacent to Broome supports invertebrate-rich tidal mudflats that also makes the bay as internationally important as a shorebird location. In 1990 it qualified for listing under the international Ramsar treaty for the protection and wise use of wetlands. Roebuck Bay is the first place many migratory birds land during their annual migration from breeding grounds as far away as Arctic Siberia.

Roebuck Bay has also been nominated to join the East Asian-Australasian Shorebird Site Network, as it is recognised as one of the three most important sites in Australia for shorebirds, both in terms of the number of shorebirds occurring there, and in terms of the number of shorebird species it supports (Watkins, 1993). The species rich faunal community of the intertidal mudflats of Roebuck Bay is recognized by CALM as a TEC and listed as vulnerable.

One of the better studied near shore island systems is the Lacepede Islands to the North of Broome. These are important breeding sites for many seabirds such as Brown Booby, Lesser Frigatebird, Pelican and Common Noddy. The colonies for the Brown Booby are the largest in the world, whilst the Lesser Frigatebird the largest in Indian Ocean (MPRSWG, 1994). The islands are a major rookery for green turtle and to a lesser extent for flatbacks. Due to their proximity to the coast they are prone to potential disturbance. A permit is required from CALM to visit the area.

There are many islands in the Kimberley IMCRA zone, with most being relatively close to shore. In some situations these provide habitats for native animals that are free from introduced predators. Many of these islands are uninhabited and rarely visited which creates issues such as fire management. The

islands of the Buccaneer Archipelago are the most visited and also have been identified as needing protection.

Other areas of importance for marine species include the Rowley Shoals and other offshore islands such as Scott, Browse and Adele Islands, which are renowned for seabird and turtle nesting. These have differing levels of protection and were identified in the Wilson report (MPRSWG, 1994) as being worthy of upgrading to protection as marine reserves. There is very little visitation to the other offshore atolls such as Scott, Browse and Ashmore except for differing levels of fishing activity from Indonesian fishermen (some legal and some illegal). In 1986 a coral survey of Ashmore and Cartier Reefs collected a total of 56 genera, represented by 255 species (Berry, 1993).

Pilbara Coast

The islands, sand shoals and mainland of the Pilbara, rise above submarine plains. These sub-tidal plains are characterized by extensive limestone pavements, large sheets of shell gravel, sand and muddy sand/ gravel. Within these habitats there are also rocky reef platforms, sand shoal and filter feeding communities that cover a much lower percentage of the shoreline areas (CALM, 2000 and MPRSWG, 1994).

The mangroves along the Pilbara coastline are the largest single unit of relatively undisturbed tropical arid zone mangrove habitats in the world (Environmental Protection Authority, 2001). The Pilbara mangals are structurally complex, but with fewer species (five) than those of the Kimberley, due to the semi-arid climate (IMCRATG, 1998). There are few places in the world where mangals occur in arid conditions, and for this reason they are of international scientific importance (Environmental Protection Authority, 2001, IMCRA, 1998 and MPRSWG, 1994*).* This habitat has a high ecological value for region, pertaining to productivity for feeding grounds and fish nurseries, and for scientific reasons of heritage, research, education and preservation of biodiversity (Environmental Protection Authority, 2001 and Semeniuk, 1997).

Rocky shoreline is common to the region and it has a medium productivity due to harsh environment. The intertidal zone experiences a wide range of temperatures, wave action, salinity and moisture levels and hence organisms in these zones require the ability to:

- move with the tides;
- protect themselves from these changes; and/or
- have mechanisms to tolerate these changes

An array of organisms such as molluscs, crustaceans and various species of algae inhabit these areas.

Intertidal mud and sand flats are a major feature of both the mainland and islands shores of the Pilbara, usually associated with fringing mangals in bays and lagoons due to the large tidal range experienced in the region (IMCRATG, 1998 and MPRSWG, 1994). Sandy beaches provide important nesting sites for sea turtles and wedge tailed shearwaters (CALM, 2000 and MPRSWG, 1994). The sediment size and organic content of both the mud flats and sandy beaches vary throughout the sub-region however, the flats are well recognised as supporting rich and diverse faunas of burrowing invertebrates (CALM, 2000 and NPRSWG, 1994).

The sub-tidal areas of sand and fine rubble are densely populated by burrowing invertebrate species such as worms, crustaceans, gastropods (snails), bivalve molluscs and echinoderms. Macroalgae and algae also inhabit these areas and sub-tidal reef platform substrates and as primary producers provide energy and food for other organisms. At some sites, strong tidal currents provide good conditions for filter feeding organisms, such as sponges, corals, sea squirts and molluscs. Algal beds also provide habitat for other molluscs, sea urchins, crustaceans, sea stars and fish.

Seagrass communities are found on sub-tidal areas with finer sediment habitats. Seagrasses are also primary producers however, are more “advanced” plants than algae due to the developed vascular

system, flowers and seeds. Six species of seagrasses occur in the Pilbara, dispersed through the macroalgae and algae communities. Seagrasses provide important food sources for animals such as dugongs and turtles (CALM, 2000 and MPRSWG, 1994).

Coral communities in the Pilbara have been well surveyed in the Dampier Archipelago and the Montebello/ Barrow Island areas. The Dampier Archipelago is a group of islands with rocky reefs, coral reefs, and shoals rising from a submarine plain. It is an area rich in natural resources, identified in the Marine Parks and Reserves Selection Working Group established in 1986, as an area worthy of Marine Reservation (MPRSWG, 1994).

The Archipelago supports an array of marine life, from mammals, reptiles and birds to barnacles, amphipods and worms. Species diversity in the marine habitats in the Archipelago is high, with more than 800 species recorded of marine benthic flora, 221 identified sponges (Porifera), 229 species of hard (Scleractinian) corals, 426 species of Crustacea, 695 species of molluscs, 286 species of Echinoderms and over 650 species of fish (CALM, 2000; Jones, 2004; Wells *et al.* 2003).

The Montebello and Barrow Island system was also identified by the Marine Parks and Reserves Selection Working Group as an area worthy of Marine Reservation (MPRSWG, 1994). The islands have recently been gazetted as Marine Conservation Reserves, with both Marine Park and Marine Management Areas in December 2004.

The area has a high biodiversity. Surveys by the Western Australian Museum recorded 257 fish species, 635 mollusc, 85 crustacean, 170 echinoderm and 150 coral species. (CALM, 2000; Berry and Wells, 2000).

The area is currently visited by limited numbers of tourist operators and few recreational users. Barrow Island is also used for commercial activities. Oil was discovered on Barrow Island in 1964 and since that time the Barrow Island Project has become the State's largest oil-producing project, valued at over $4.8 billion. Although Barrow Island is a nature reserve, Chevron Australia's lease covers virtually the whole island and the company is responsible for ensuring that operations do not negatively impact on the conservation values of the area.

Notable fauna occurring in the Pilbara coast region include whales and dolphins. There are about 76 species of whales and dolphins in the world, and 36 of these are known to visit the WA tropical and subtropical coastline. The other group of marine mammals found in the Pilbara is the group called "Sirenia", which is represented by one species, the dugong (*Dugong dugon*). Dugongs are shy, herbivorous and relatively long-lived (70-plus years).

Of the 93 species of seabirds that occur along the West Australian coast, 17 are known to nest in the Montebello/ Barrow Island and Dampier Archipelago areas. No surveys have been conducted in the island areas during the spring and autumn months, which is the peak time for sighting migratory waders so there is limited information on migratory seabirds and waders. Nonetheless it is recognised that there is a wide range of species that visit the area. International treaties with Japan and China (JAMBA & CAMBA Agreements) cover many of these species, and therefore Australia has an obligation to protect these species and their habitats.

Marine reptiles are well represented in the Pilbara region, with 11 species of sea snake, five species of marine turtle and the saltwater crocodile all found in the Pilbara. Australia is one of the few countries in the world to still have relatively large turtle populations, and all are listed as protected by the *EPBC Act, 1999* and as threatened under the *Wildlife Conservation Act 1984.* The five species found in the Pilbara are the loggerhead (*Caretta caretta*), green (*Chelonia mydas*), flatback (*Natata. depressa*), hawksbill (*Eretmochelys imbricata*) and leatherback (*Dermochelys coriacea*) turtles.

Gascoyne Coast

Exmouth Gulf is part of the Pilbara Nearshore Bioregion and provides productive ecosystems consisting of diverse invertebrate communities, mangrove communities and inter-tidal mudflats. The mangroves on the eastern side of Exmouth Gulf are amongst the largest single unit of relatively undisturbed tropical arid zone habitats in the world (Environmental Protection Authority, 2001). There are a number of arid zone mangal communities in Exmouth Gulf that are considered regionally significant, including the Bay of Rest, Giralia Bay to Yanrey Flats to Exmouth East Shore, Ashburton Delta River (area south of Onslow). These mangroves are protected by Environmental Protection Authority Guideline 1.

Other major natural attributes of the Exmouth Gulf are the filter-feeding communities which include cnidarians, tunicates and sponges. The areas in the northern part of the Gulf are highly developed sponge gardens with a diversity of marine life. Mapping of these communities is inadequate and more research and survey into these communities is recommended. These communities of Exmouth Gulf provide habitats for juvenile fish, breeding and nursery grounds that are of high biodiversity, cultural and scientific value. The gulf also supports dugong populations and provides resting areas for humpback whales with calf.

The Muiron Islands are two medium sized, sparsely vegetated islands that lie at the Western end of Rowley Shelf. They are managed Crown Reserves for recreation and flora and fauna conservation, and are managed with prepared management plans.

The Ningaloo Reef on the western side of Cape Range is the largest fringing reef in Australia stretching some 290 kilometres along the Gascoyne coast and harbouring a high diversity of coral, fish, algal and filter-feeding communities. The majority of Ningaloo Reef falls within the Ningaloo Marine Park, which is managed by CALM. The Ningaloo Marine Park has been extended to include the coastline as far as Red Bluff and northwards to the Muiron and Sunday Islands. The Management Plan for Ningaloo Marine Park and Muiron Islands Marine Management Area 2005-2015 has been adopted (CALM and MPRA, 2005).

Ningaloo is part of the system of coral reefs of the west coast of Western Australia which constitute one of the 18 hotspots of coral reef biodiversity in the world. Other reefs included are, the outer islands of Shark Bay, Houtman Abrolhos Islands, and Pocillopora Reef at Rottnest Island. The reefs are 7th in total diversity, 2nd in restricted range species, and 15th of the 18 in human induced threat (Roberts *et al*, 2002)

Coral diversity in Ningaloo is moderately high consisting of 217 hermatypic coral from 54 genera (IMCRATG, 1998). Corals are the most important ecosystem building blocks in the Ningaloo Reef. They provide habitat, food and shelter for a wide variety of marine flora and fauna. Invertebrate communities and fish fauna are also diverse with around 600 species of mollusc and more than 90 species of echinoderms (eg seastars, sea cucumbers, sea urchins) and 500 fish species representative of temperate, sub-tropical and tropical affinities being recorded. Three hundred and ninety three species have been recorded from the Muiron and Sunday Islands to the north of the reef.

Soft sediment communities are among the most poorly understood communities and occur in deeper offshore waters and in shallow lagoonal areas of Ningaloo Reef. They include a surface film of micro-invertebrates that are an important food resource for many invertebrates in the area. The loss of these micro-organisms can result in increases in turbidity (CALM and MPRA, 2004). Soft sediment communities are extremely important for the conservation of biodiversity due to the high diversity of invertebrates found throughout these communities. These communities and the role they play in ecosystem function is poorly understood.

There is an abundant shark and ray population in the region. These include whale shark (*Rhincodon typus*), tiger shark (*Galeocerdo cuvier*), hammerhead (*Sphyrna spp*.) grey reef shark (*Carcharhinus amblyrhynchos*), white-tip reef shark (*Triaenodon obesus*), black-tip reef shark (*Carcharhinus meanopterus*), tawny nurse shark (*Nebrius ferrugineus*), manta ray (*Manta birostris*), blue spotted mask

ray (*Dasyatis kuhlii*), white spotted eagle ray (*Aeotobatus narinari*), giant sting ray (*Plesiobatis daviesi*) and cowtail stingray (*Pastinachus seplen*).

Sparse, scattered seagrass communities and clusters of mangrove communities occur around Yardie Creek and Mangrove Bay on North West Cape. Although there are seasonal streams that flow into the Ningaloo region during heavy rainfall and seasonal storms, there are no estuaries located in this region.

Dugongs occur in relatively large numbers in the Ningaloo Reef. Preen and Marsh (2004) estimated approximately 1,000 individuals in Ningaloo Marine Park. Seagrass beds and shallow lagoons provide valuable food sources for dugong.

Four species of marine turtle are known to occur at Ningaloo. All are listed threatened species under the *EPBC, 1999* and the *Wildlife Conservation Act 1984,* however, only three are known to breed in significant numbers. These are Green turtle (*Chelonia mydas*), Loggerhead turtle (*Carretta carretta*) and Hawksbill (*Eretmochelys imbricata*).

There is significant green turtle nesting on Muiron and Sunday Islands and on North West Cape in the northern area of Ningaloo Reef. The North West Shelf represents one of the last strongholds for hawksbill turtles in the world. Loggerhead turtle rookeries are found in the southern areas of Ningaloo Marine Park and there are significant rookeries located at Shark Bay.

The waters surrounding the Islands have prolific coral growth and are important seabird and turtle nesting rookeries. Sunday Island lies nearby and together these islands provide prime recreation and tourism opportunities in the Ningaloo Region. In addition, the area surrounding the islands is highly prospective for hydrocarbons and exploration. The waters surrounding the islands are proposed as Muiron Islands Marine Management Area.

A total of 144 bird species have been recorded on Ningaloo Marine Park (MPRA and CALM, 2004). Of these, 33 are seabirds and 20 are migratory shorebirds. Key rookeries on Northwest Cape/ Ningaloo region include Mangrove Bay, Mildura Wreck, Fraser Island and it is likely that mangrove communities in the Gulf of Exmouth and the Sunday and Muiron Islands also provide habitat for shorebirds. The migratory birds are protected by bilateral agreements between Australia and the Chinese and Japanese Governments through the CAMBA and JAMBA agreements. Lake MacLeod, north of Carnarvon, is under investigation for listing as a Ramsar wetland of international significance, this area also provides important habitat for migratory waders.

The Shark Bay area is another important locality for marine biodiversity. It was listed as World Heritage Area in 1991 based on its outstanding universal values including evolutionary history, representation of geological processes, biological evolution and human interaction with the natural environment. It has certain unique rare and superlative natural phenomena, and it shelters some of the most important habitats for threatened species in the world (CALM, 2000). It covers approximately 2.2 million hectares of which 71 percent is marine environment and the other 29 percent coastal areas.

Within the bay there is a strong mixing of temperate and tropical species and the presence of three biotic zones in the marine environment which contributes to the region's high biodiversity value. Faure Sill provides a wedge between the hyper-saline gradients and meta-saline environments creating conditions that have given rise to the development of stromatolites. This makes Shark Bay one of only two sites in the world where these life forms exist in modern sedimentary environments. Consequently, it is of great interest to the international science community.

The stromatolite communities contain the most diverse and abundant examples of prokaryotic stromolitic microbialites in the world and the world's best example of three-dimensional grazing stromotalites (www.sharkbay.org) dating back 3,500 million years. Limestone sands that were common in ancient geological times also exist here and provide evidence of geological processes and evolutionary history.

The area supports more than 4000 square kilometres of seagrass with 12 species occurring in shallow carbonate sand banks and tidal flats. These seagrass communities support a rich invertebrate fauna

associated with abundant epiphytic growth and one of the world's largest dugong populations (estimated between 10,000 and 15,000 individuals). Dugong populations have been assessed as satisfactory, though data indicates that the percentage of calves has declined. This requires further investigation. Dugongs are at threat from loss of habitat and from human interactions through boat strike. In Shark Bay Indigenous hunting of Dugong occurs.

Mangal communities fringing the northeastern shore south of Carnarvon consist of a single species (*Avicennia marina*). Mangals also occur at several locations on the central and western coasts of the region. These mangal communities are species rich, including a number of snail species that inhabit northern Australia and the locally endemic subspecies *Littoria cingulata pristissini.*

Shark Bay is an important nursery ground for crustaceans with exceptional abundance of benthic invertebrate fauna with diversity and zoological significance. Carbonate sandbanks of Shark Bay support epibenthic invertebrate fauna including species of bivalve molluscs with a significant proportion of southern Australian and west coast endemic species. Coral reef communities occur along the outer islands of Shark Bay.

Shark Bay supports 323 species of fin-fish, largely top predators including tiger sharks (*Galeocerdo cuvier*), whalers and hammerheads (*Sphyrna spp*.). Most of the fish species found in the bay are common to the Indo-Pacific ranging from the eastern shore of Africa to Micronesia. The Manta ray (*Manta birostris*) and other smaller more abundant rays are also found in Shark Bay waters.

There are two species of marine turtle found at Shark Bay – the green and loggerhead turtles. The area is significant for the breeding of loggerhead turtles and provides the largest loggerhead turtle rookery in Western Australia. Research and monitoring programs include a tagging and tracking program at Dirk Hartog Island.

In Shark Bay, there are over 35 shorebird species that have been protected under agreements, five of which are known to breed in the shelter habitats provided.

The biodiversity of the Zuytdorp region is relatively sparse with the little available information suggesting that rocky shore inter-tidal communities comprise a mixture of Indo-West Pacific, West Coast endemic and temperate southern Australian species. The algal mats that cover the rocky reefs are abundant however little is known about these communities. The Murchison River mouth is the only estuary in this region.

There are two Fish Habitat Protection Areas, which have been declared under the *Fish Resources Management Act 1994* for the purposes of: the conservation and protection of fish, fish breeding areas, fish fossils or the aquatic ecosystem; and the management of fish and activities related to the appreciation and observation of fish. These include the Point Quobba and Miaboolya Creek Fish Habitat Protection Areas. There is a diverse fin-fish fauna representing a unique mix between south west, west coastal Australian and tropical and temperature indo-pacific species. Miaboolya alone supports over 120 fish species where nearshore mangroves, salt marshes and algal mats provide nursery and breeding areas for key recreational species such as tailor, mulloway, sand whiting, dart and tarwhine. Miaboolya Creek has a combination of biodiversity, cultural and fish resource management values.

Twenty species of cetaceans (whale and dolphin) have been recorded in the Gascoyne Coast region. Whales and dolphins are protected by the *WA Wildlife Conservation Act 1950* and the *Environmental Protection and Biodiversity Conservation Act 1999*. Monkey Mia is home to two species of dolphin – bottle nose dolphins (*Tursiops truncatus*) and Indo-Pacific bottlenose dolphins (*Tursiops aduncus*). The Monkey Mia dolphins provide a human interaction experience controlled by CALM, which attracts thousands of tourists every year to the region.

Humpback whales travel through the Gascoyne on their northward migration to the Kimberley breeding and calving grounds in winter and a southward migration to Antarctic feeding grounds during August to October. Shark Bay and Exmouth Gulf are utilized as a resting ground for females and calves on the

southern migration (Department of Fisheries, 2002). During their southern migration, Exmouth Gulf and Shark Bay forms an important resting area for females and calves.

There is scope in this region to undertake community monitoring programs for cetaceans. Other management strategies will include ensuring that there is minimal impact to the species as a result of human interaction via nature-based tourism or recreational boating.

Nullarbor Coast

There is relatively little information on the biophysical values of the Nullarbor coast and there are very few scientific publications on its biodiversity values. The marine systems are influenced by the the east flowing Leeuwin Current, which varies considerably in strength, temperature and position in the Great Australian Bight waters. The area represents the most easterly influence of the Leeuwin Current and it is geographically very isolated.

The marine flora and fauna of the Nullarbor coast are also poorly researched or documented. The intertidal zones are dominated by algal and seagrass communities, possibly with high levels of species endemism and rareness. Low nutrient levels in the marine environment suggests that primary production and trophic systems are probably driven by nutrients and particulate matter released during breakdown and decay of seagrass and algae, which piles up in high seaweed wracks on the shore. These macroalgal and seagrass beds are likely to support high biomass of molluscs, echinoderms and ascidians, similar to adjacent South Australian waters in the Great Australian Bight Marine Park.

The area supports 17 cetacean species as well as two threatened pinniped species – Australian Sea Lion and New Zealand Fur Seals. There are significant migratory routes for southern right whales and other cetacean species such as Blue Whales and Humback whales. A coastal breeding colony of Australian Sea Lion has been noted on Baxter Cliffs at Twilight Cove.

The Great Australian Bight is an important nursery area for the Australian Salmon, the Australian Herring and Pilchards. It also is a rich fishing ground for the Australian shark fisheries. Further research is required on the fish and shark population dynamics, the ecological function and biodiversity values of this marine environment in order to inform sustainable fisheries management in these waters.

2.8.9 Major Uses and Values of Marine Biodiversity

Tourism

The economic impact of tourism varies widely across the Rangelands, depending on the local attractions. The expenditure of visitors in the Rangelands areas in 2001/02 was approximately $1.29 billion, which is about one quarter of the State's total value of tourism.

It is difficult to identify how much of this is directly related to the Rangelands' marine resources, but it is a major part of the promotional material of the tourism industry. The marine biodiversity and natural wonders of the region give rise to important nature-based tourism, which is a major industry along the entire Rangelands coast. Marine tourism is becoming increasingly important for the long-term viability of many regional communities.

Conservation

Marine biodiversity forms a foundation for marine resources that are valuable for humans and sustaining life on earth. For these primary reasons, marine biodiversity has a high conservation value.

Living marine resources provide essential economic, environmental, aesthetic, and cultural benefits to community, industry and humanity as a whole. Sixteen percent of the animal proteins consumed worldwide come from the sea. In addition, marine products provide important fertilisers for livestock,

medicines, ornamental marine life and bioprospecting opportunities. The other direct conservation values include eco-tourism, recreation, research and education.

Furthermore, the maintenance of biodiversity resulting in intact, healthy ecosystems provides local and global benefits. Marine ecosystems provide natural carbon sinks (storage), atmospheric gas regulation (eg enormously productive phytoplankton), nutrient cycling and natural waste treatment. Coral reef, mangrove and marco-algal communities protect coastal areas from erosion, and intensive storm events. Globally, these indirect values have been estimated at $5.2 trillion per annum for open oceanic ecosystems and $11.7 trillion for coastal ecosystems (Costanza *et al*, 1997).

There is also a plethora of non-use values of marine biodiversity centred on spiritual, cultural and aesthetic values, which are not captured by current market or economic models, but are interwoven within our appreciation of the sea and its inhabitants. This appreciation simulates the high "conservation value" for the sea and the fragile life held within it.

There are globally significant biodiversity values associated with the Rangelands' marine biodiversity including:

- six of the world's seven species of marine turtle;
- migratory bird feeding and breeding areas;
- Roebuck Bay and Eighty Mile Beach Ramsar Wetlands;
- Shark Bay World Heritage Area pending nomination Ningaloo;
- Migration of whale sharks to the Ningaloo Coast
- ancient stromatolite ecosystems;
- large seasonal aggregations of whales;
- large stretches of intact mangrove communities;
- the world's largest population of dugong; and
- a diversity and abundance of invertebrate fauna giving rise to productive systems.

Commercial Fishing

The commercial fishing values of the Rangelands' State waters are extensive, contributing a substantial amount to the State's economy. Commercial fishing in the Gascoyne region alone derives between $78 million and $254 million annually depending on the season, accounting for approximately 33 percent of the State's total output from commercial fishing.

In the Kimberley, there is a variety of commercial fisheries that contribute approximately $12 to 15 million annually. These fisheries include the Broome Prawn, Kimberley Prawn, Kimberley Gill net, Northern Demersal Scalefish, Mackerel and Shark Managed Fisheries. Some of the major species caught in the Kimberley include Barramundi and Giant Threadfin Salmon, red emperor and gold band snapper. Other minor target species in the Kimberley include mudcrab, aquarium species, and beech de mer.

Key commercial fisheries in the Pilbara including Onslow Prawn Managed Fishery: (king prawns (*Penaeus latisulactus*), tiger prawns (*P. esculentus*), endeavour prawns (*Metapenaeus spp.*) and banana prawns (*P. merguiensis*)); Nicol Bay Prawn Fishery; Pilbara Demersal Finfish Fisheries, Mackeral Fishery and the Northern Shark Fishery (throughout Pilbara and Kimberley).

In the Gascoyne fisheries constist of the Shark Bay Prawn Managed Fishery; Shark Bay Scallop Managed Fishery; Exmouth Gulf Prawn Managed Fishery; Shark Bay Snapper Managed Fishery; Shark Bay Beach Seine and Mesh Net Managed Fishery; Marine Aquarium Managed Fishery; Specimen Shell Managed Fishery; Mackerel Interim Managed Fishery; West Coast Demersal Gillnet and Demersal Longline Managed Fishery; West Coast Deep Sea Crab Interim Managed Fishery (under other legislative means); Shark Bay Crab Experimental Fishery; Wetline Fishery; Beche De Mer Fishery;

Exmouth Gulf Beach Seine Fishery and the blue swimmer crab fishery (Shark Bay Crab Experimental Fishery).

On the Nullarbor coast a range of commercial fisheries exist including Southern Rock Lobster (*Jasus edwardsii*), Greenlip, Brownlip and Roe's abalone, Demersal Gillnet and Demersel Longline Fisheries: target species include Dusky Shark (*Carcharhinus obscurus*), Whiskery Shark (*Furgaleus macki*), Gummy Shark (*Carcharhinus plumbeus*) and the incidental catch of other sharks and scalefish (Snapper, Groper and Dhufish) (Department of Fisheries, 2004a). Some of the key shark species in the region include the Dusky Whaler shark (*Carcharinhus brachyurus*) and Whiskery shark (*Furgaleus macki*) which have been noted by Department of Fisheries as being over-exploited (Department of Fisheries, 2003). The management of this fishery is being reviewed to address these sustainability concerns with new management measures to be introduced by 2005.

The Department of Fisheries is responsible for the management of commercial fishing in accordance with the *Fish Resources Management Act 1994.* Management strategies include limitations on fishing gear, temporal and spatial closures, limits to the number of licenses issued, Total Allowable Catch and monitoring of the catch and effort levels. In addition, all export fisheries have undergone Ecological Sustainable Development Assessments by the Department of Environment and Heritage under the *EPBC Act 1999* to ensure fisheries protect biodiversity and ecological processes whilst safeguarding economic returns and community well being for current and future generations.

Recreational Fishing

Fishing is one of the most popular recreational activities in Australia and the coastlines of the Nullarbor, Gascoyne, Pilbara and Kimberley provide some of the best recreational fishing locations in the country. This is due to a high habitat diversity supporting diverse target recreational fish species combined with relatively high access to the resource.

The value of recreational fishing in the Kimberley is unquantified but substantial. For example, the Ord River barramundi fishery was estimated to generate $1.14 million in spending by local residents in 1996 (Kewagama Research, 1997). Another figure indicating its popularity is that Broome boat ownership rate is third highest in Western Australia and very few of those boats are regularly used for activities other than fishing. Unfortunately there have never been any dedicated creel surveys for the Kimberley to calculate fishing effort or catch.

The Kimberley in 2004 has had its first extensive review of bag and size limits for recreational fishing. This process is nearing completion and it is hoped that the new regulations will come into place in 2005. This represents a major milestone as the new regulations will better reflect reasonable limits for tropical species.

Data exist from creel surveys undertaken on the Gascoyne and Pilbara coasts to provide estimates on the recreational fishing catch from shore based and vessel fishing. The latest data from the Pilbara in 1999/ 2000 suggests that fishing effort was 190,000 fisher days. The total recreational catch for all scale fish species for the region in 1999/ 2000 was estimated at 300 tonnes, excluding charter vessels. This equates to approximately 12 percent of the commercial demersal scalefish catch for this sub-region during the same period (Department of Fisheries, 2004). In the Gascoyne, the total annual recreational fishing effort was 243,000 fisher days for 1998/ 1999. This comprised 113,000 fisher days by boats launched from public ramps, 53,000 fisher days by boats launched from beaches and 77,000 days by shore-based fishers (Sumner *et al*., 2002).

Gascoyne target species includes include pink snapper (Pagrus auratus), spangled emperor (Lethrinus nebulosus), sweetlip emperors (Lethrinus miniatus), yellowtail emperor (Lethrinus crocineus), mackerel (Scombridae spp), squid and crayfish species.

The Northern Rangelands mangrove communities, rivers, oceanic and coastal waters provide a variety of marine, freshwater and estuarine species such as barramundi (*Lates calcarifer*), tropical emperors

(*Lethrinus* spp.), seaperches (*Lutjanus* spp.), trevally (*Carangidae* spp.), sooty grunter/black bream (*Hephaestus fuliginosus*), king threadfin salmon (*Polydactylus macrochir*), mud crabs (*Scylla* spp.), cods (*Melanonidae*, *Moridae* spp.) Spanish mackerel (*Scomberomorus commerson*), tuna (*Scombridae* spp.), sailfish *(Istiophorus platypterus*), queenfish (*Scomberoides* spp.) and cobia (*Rachycentron canadum*).

Offshore islands in the northern Rangelands provides recreational fishing with target species including the demersal seaperch family (Lutjanidae) such as red emperor (*Lutjanus sebae*), coral trout (*Plectropomus* and *Variola* spp), trevally (*Carangidae* spp.), tuskfish (*Choerodon* spp), tuna (*Scombridae* spp.), mackerels (*Scombridae* spp), sharks and billfish (Department of Fisheries, 2004).

Target recreational species on the Nullarbor coast include snapper, swallowtail, trevally, cod, salmon, herring and leatherjacket species.

Recreational fishing is an important activity among Aboriginal communities along the Rangelands coast. There are cultural connections to many of the target species, thus fishing and hunting for Aboriginal people extends beyond a form of recreation. Hunting of green turtle and dugong is also a significant resource use by Aboriginal people in particular places within the Region. The management of such resources extends to the Australian Government under the *EPBC Act 1999*; one example of this being the Sustainable and Legal Indigenous Harvest of Marine Turtles and Dugongs in Australia - A National Approach (DEH, 2005).

The Department of Fisheries is responsible for management and enforcement of fisheries management policies and legislation in State waters including in CALM managed MPAs. The Department of Fisheries uses a number of tools to assist in the management of recreational fishing, including bag limits, gear restrictions, seasonal closures and licences.

Aquaculture and Pearling

The largest sector of this group is the Australian *Pinctada maxima* pearl oyster industry, valued at $130 million throughout the Pilbara, Gascoyne and Kimberley regions. It is the most valued aquaculture industry in Western Australia and second only to the State's rock lobster fishery in the value of its export earnings.

Most of the culture uses *P. maxima*, which is either caught as wildshell or hatchery reared spat. These are seeded to produce what are marketed as South Sea Pearls. There are 16 licences, all of which have been active over a decade or more. The wildshell collection operates under a three zone quota system and stocks were assessed as being fully exploited within the management parameters of diver safety and the maximization of the value of the pearl crop in 2002 (Department of Fisheries, 2003).

The Kimberley, particularly Broome, provides a substantial contribution to the Australian pearling industry. The pearling industry, its products and its rich history also provide major tourist attractions.

Other species of interest include tropical abalone, aquarium fish, trochus, caged barramundi and prawns for the Kimberley but none are currently operating at substantial level. There are several proposals and pilot programs currently underway for the expansion of prawn and barramundi farms.

Aquaculture production is a significant natural resource value in the Gascoyne. In the Gascoyne there has been significant investment in the culture of non *P. maxima* pearl oyster species, but all other aquaculture activities are in early developmental stages. At present, the aquaculture industry comprises mainly pearl oyster production from commercial and hatchery operations in the Exmouth Gulf and Shark Bay areas. There is also a growing industry for prawn nurseries and the painted rock lobster and green rock lobster in the Gascoyne. In addition, there is growing interest in the production of estuary cod (*Epinephelus coioides*), dolphin fish or mahi mahi (*Coryphaenidae hippurus)*. Marine ornamental finfish culture is progressing with the production of sea horses and juvenile clown fish. Exmouth Gulf and Shark Bay have been identified as key areas for aquaculture industry production in Western Australia.

2.8.10 Major Threats to Marine Biodiversity

Marine Pollution – Declining Water Quality

Key marine pollution contributors on the coast include sewage from townships, oils and hydrocarbons from vessels, litter and fishing refuse and (potentially) ballast water, which can lead to the introduction of invasive exotic species.

Environmental water quality along the coast of the Rangelands varies. However, in general marine pollution is caused from altered nutrient levels, additions of toxic contaminants and lowered water clarity or increased turbidity. There are also issues with increasing light and noise pollution, (particularly for turtle nesting and hatchlings) from industry and recreational activities on the coastal and island areas. In addition, seagrass communities are susceptible to impacts from water quality degradation caused by events such as oil spills, septic tank leaks and nutrient enrichments from land based activities. Other pressures to these communities can include propeller damage, anchorage and turbidity caused from intense boating activity and uncontrolled sewage disposal from vessels.

Some examples of toxic contaminant sources:

- shipping activity/ recreational boating (antifouling agents eg TBTs, loading spillage, cleaning of decks/ facilities, oil/ fuel, litter especially plastics);
- industrial point sources (process wastewater, produce formation water, bitterns, heat);
- domestic outflow (stormwater, processed waste);
- catchment runoff (upstream mining/ industry, agriculture, urban sources); and
- disturbance of acid sulphate soils.

Some examples of altered nutrient level sources:

- industrial and domestic discharge (eg. produced formation water, sewage) from islands, coast and other structures (eg. house boats);
- deposition of nutrients from particulate emissions from industry; and
- catchment runoff (N.B. wide fluctuations in runoff are natural due to episodic rainfall events in the Rangelands, however disturbances resulting from land-use may increase level of nutrient input associated with runoff).

Water clarity and turbidity - Increased sediment loading due to:

- dredging (port channel maintenance) and port extensions;
- altered hydrology/ water flow – due to manmade structures/ industry development (eg. causeways, wharfs, channels, pipelines); and
- catchment run-off (N.B. wide fluctuations in runoff are natural due to episodic rainfall events in the Pilbara, however disturbances resulting from land-use may increase level of sediment in runoff).

The lack of coastal infrastructure for waste management and disposal has implications for biodiversity conservation and industry groups throughout the Rangelands. Advanced waste management facilities that allow for the treatment and degradation of hydrocarbon substances on land are unavailable at ports, boat harbours and marinas throughout the region. A regional and cross-regional approach to waste management is essential in relation to the disposal of refuse, grey water, black water and the potential risk that ballast water causes by introducing marine pests. A coordinated approach is required between government and industry groups with community support.

Unsustainable Fishing

The major threats to marine biodiveristy in the Region include unsustainable fishing pressure of target species by commercial, charter and/ or recreational fishing, incidental catch, physical disturbance of important habitats, cascading trophic interactions, removal of predator fish, ghost fishing and fish feeding

(MPRA and CALM, 2004). Adverse impacts of overfishing fishing are amplified when combined with other threats such as declining water quality from land based and marine based pollution, loss of habitat from direct removal and indirect cumulative impacts, climate change and trans-national issues such as straddling fish stocks and illegal fishing.

Other threats include wastes generated through boating and fishing including marine debris from improperly disposed of fishing refuse, propeller damage, and in some cases destruction of dune systems due to accessing remote fishing areas.

An example of a fishery that has been overfished is the Shark Bay Pink Snapper, identified as being over fished through a recreational fishing survey conducted in 1998. To respond to excessive fishing pressure, the Department of Fisheries, with support of industry and community, introduced a Total Allowable Catch (TAC), setting aside explicit catch allocations for commercial and recreational sectors. Early indications are that the stock is recovering strongly and there will be fish for the future.

Impacts of Exotic Species and Disease

Western Australia receives more bulk carriers and therefore ballast water than any other State. It is estimated that Western Australian ports receive 49 percent of the country's bulk carriers.[4], predominantly into northwest ports. With this high amount from international and domestic shipping, there is inevitably a high risk of introduced marine pests via ballast water, bilge water and hull attachments.

There have been only limited marine pest surveys undertaken in the Rangelands. For example, only a few major ports such as Port Headland have been surveyed for introductions. One area beyond a port that has been recently surveyed is the Dampier Archipelago. They documented no outbreak of an introduced marine pest species in the Dampier Archipelago. However, there is evidence of the presence of pest species, such as *Drupella* and Crown of thorns starfish (*Acanthaster planci),* which are presently found at low numbers, and are likely to be native to the area. The recent biodiversity survey by the Western Australian Museum will enable future introductions to be confirmed as 'introduced' from the various species that have currently been identified as inhabiting the area, as currently it is unkown whether some species have been introduced or occur naturally.

The Kimberley marine environment appears to be largely free of introduced plants and animals, although this is difficult to state categorically as there have been no formal surveys for introduced marine pests at its ports.

Key management measures include the control of pest species and the prevention of introduced marine species into the waters of Rangelands. This will require cooperation across regions and in some areas, across jurisdictional boundaries.

2.8.11 Current Management of Marine Biodiversity

Management Bodies

Conservation of marine biodiversity by the State is achieved using a suite of tools such as fisheries management plans, fish habitat protection areas, seasonal closures and Marine Protected Areas (MPA's). The State is committed to the development of a Marine Protected Area system. A MPA system consists of Marine Conservation Reserves (MCRs) that are vested to the Marine Parks and Reserves Authority (MPRA). The MPRA provide policy advice to the Minister for the Environment and audit management plans prepared by CALM. CALM is responsible for the management of MCRs including the:

- preparation of management plans;
- implementation of the management plan;
- co-ordination with other agencies;

[4] Ships which are not fully loaded carry ballast for safety reasons so that they float deeper in the water.

- implementation of education and monitoring programs;
- wildlife research and management (includes *Wildlife Conservation Act 1950* threatened species recovery plans and wildlife management programmes);
- management of nature-based tourism; and
- lead role in enforcement (non-fisheries issues).

CALM also ensures that management of MCRs is integrated with adjoining mainland and island conservation reserves.

Concurrent to the MPA system is the protection of threatened species and communities under the Wildlife Conservation Act. Marine species and communities can be listed under the same categories of threat warranting special protection as terrestrial and aquatic species and communities. For a complete list of threatened species see Appendix V. There are no marine specific threatened ecological communities, though the Roebuck Bay Mudflats are listed.

There is a clear threat from potential industrial accidents and spillages to the marine environment. The State Government has developed a Marine Pollution Atlas to effectively manage such events if there were to occur. A major focus for the Atlas is the Pilbara.

The Department of Fisheries manages, researches and regulates commercial and recreational fishing, aquaculture and pearling while protecting and conserving the various related ecosystems in all State waters. This includes having the lead role in enforcement of fisheries legislation that helps protect fisheries resources in all waters including the marine parks and reserves established under the *Conservation and Land Management Act 1984*. They also manage Fish Habitat Protected Areas (FHPAs) and report to DEH on the broader ecosystem impacts of fisheries through ESD assessment process. An outcome of the assessment process is the requirement for the Pilbara Trawl Fishery to report regularly to DEH on its progress on minimizing bycatch of protect species.

The Australian Government's Department of Environment and Heritage, administers the *Environment Protection and Biodiversity Conservation Act 1999*, which has provisions for the development of ecological sustainability plans for all export fisheries in Australia. The Department of Fisheries is responsible for the development of ESD plans which is a devolved responsibility from the Australian Government. The Australian Government also devolves management responsibilities for the management of Commonwealth marine protected areas to CALM where appropriate (eg Ningaloo Marine Park and Mermaid Reef Marine National Nature Reserve).

Another initiative includes the North West Shelf Joint Environmental Management Study or NWJEMS. This was a major marine planning and management study, beneficial for a wide range of industry types (eg commercial fishing, petroleum industry). Furthmore, the collation of scientific information is very valuable for integrated marine planning and multiple use management for ecologically sustainable development.

The development of the Pilbara Environmental Water Quality Framework is another tool that has been developed with funding under the Natural Heritage Trust through the Department of Environment. The framework has been developed through extensive community consultation, and will used to effectively monitor and manage marine environmental water quality health.

Conservation of marine biodiversity relies on maintaining ecosystem function and integrity. This in turn requires that development activities in the marine environment are managed so as to limit their impacts on marine ecosystems. The Environmental Protection Authority and environmental regulatory agencies have developed policies and management frameworks aimed at maintaining marine ecosystem function and integrity throughout the region.

The conservation of biodiversity is also a responsibility of industry and the community. For example, industries have licence conditions which place responsibility on them for the conservation of resources and associated marine biodiversity. For example, wildlife tour operators are responsible for the

implementation of relevant codes of conduct such as the whale shark code of conduct and aquaculture ventures are responsible for disease management, management of escapees and ensuring water quality parameters are maintained within recommended guidelines.

The community also has a responsibility when it comes to biodiversity conservation and management, through ensuring that recreational take of species remains within legal bag limits and size limits, activities are consistent with marine protected area management plans and zoning schemes and when visiting coastal areas, no trace of litter or refuse is left behind.

2.8.12 Marine Biodiversity RCTs and MATs

RCT17: By 2025, environmental water quality in estuarine and marine areas of the Rangelands to be maintained or improved to meet ANZECC guidelines and standards or specific geographical guidelines for water quality by 2008

RCT18: Maintain or improve the conservation status of marine and coastal native species and assemblages in priority areas by 2025

RCT19: By 2025, eradicate or reduce the abundance of significant invasive species in marine and coastal areas

RCT20: The comprehensiveness, adequacy and representativeness (CAR) of all marine and coastal ecosystems in formal protected areas is improved on a priority basis by 2015, compared to 2005 baseline

Management Action Targets		Geographic Focus	Management Actions	Potential Partner Groups	Links to RCTs	Priority
Benchmarking and Monitoring						
12 	**S12.** By 2008, marine ecosystems, values and associated threatening processes have been identified, characterised and prioritised for the Rangelands	Regional	• Identify and prioritisation of key threatening processes and values (e.g. coral bleaching, marine pests) • Identify Priority Areas • Collate traditional knowledge systems with other information • Undertake trade-off analysis • Biodiversity priority areas identified through incorporating community knowledge • Investigate human impacts on threatened species and threatened ecological communities • Investigate and ascertain impacts on areas of international significance e.g. Shark Bay and Roebuck Bay	State Industry Community Traditional Owners Research NGOs	RCT18 RCT20	1A

Management Action Targets		Geographic Focus	Management Actions	Potential Partner Groups	Links to RCTs	Priority
12 	**S13.** By 2005, marine environmental quality parameters are established for the region using ANZECC Guidelines and Standards and a monitoring program implemented by 2007	Regional	• Establish marine environmental quality guidelines for marine and coastal waters • Support the implementation of the Pilbara Water Quality Project and identify areas for expansion of this environmental quality monitoring and management framework • Establish a regional scale marine environmental quality monitoring project to include priority areas, areas of development pressures and appropriate reference sites • Support monitoring in marine protected areas as per management plans. • Continue to implement marine monitoring programs in the region consistent with other management plans	State Industry Community Traditional Owners Research NGOs	RCT17	1A
9 	**S14.** By 2006, develop and implement a collaborative comprehensive marine and coastal monitoring program for priority biodiversity areas and areas under development pressures	Regional	• Determine robust indicators for monitoring • Ensure data collection and project methodology is standardised • Develop and maintain an accessible database for the marine monitoring program • Develop and commence monitoring programs targeting priority marine and coastal ecosystems, habitats, threatened species and threatened ecological communities. Such as in marine protected areas, fish habitat protection areas, World Heritage Areas and other identified priority areas eg areas under development pressure • Monitor the impacts of climate change on marine, coastal and island biodiversity using indicator species and satellite imagery • Monitor visitor damage to corals, mangrove and seagrass communities • Identify areas for assessment new fish habitat protection areas, marine parks and marine protected areas. • Promote coordination of monitoring programs, indicators and methods across industry and government sectors. • Promote and facilitate community involvement in monitoring programs.	State Industry Community Traditional Owners Research NGOs	RCT18 RCT1 RCT19 RCT20	3B

Management Action Targets		Geographic Focus	Management Actions	Potential Partner Groups	Links to RCTs	Priority
9 	**S15.** By 2007, develop a collaborative research plan for the marine and coastal areas of the Rangelands Region in partnership with key stakeholders	Regional	• Identify priority gaps in knowledge and develop a list of priority research questions for the Rangelands Coast by 2005 • Investigate and research the distribution and abundance and ecological requirements of flora and fauna populations for management purposes • Develop a collaborative research plan for the Rangelands Coast • Implement priority research projects • Survey/classify species and ecological communities • Identify priority gaps in knowledge and develop a list for priority research • Determine the impacts of human activities on seagrass, coral, mangrove and algal communities • Determine trigger levels (criteria) as benchmarks for monitoring and evaluation, and for feedback to management • Investigate the sustainability of Indigenous harvest on native marine fauna •	State Industry Community Traditional Owners Research NGOs	RCT18 RCT19 RCT20 RCT1	3A
10 	**S16.** Quantify the impact of commercial fishing, recreational fishing and aquaculture activities on target and non- target species by 2010	Regional	• Quantify species and level of take from the records of Department of Fisheries • Identify knowledge gaps to be addressed • Review the accidental take of iconic species (eg turtle and dugong) and non target fish species • Identify the mechanisms used within industry to mitigate accidental take of iconic species • Quantify the impact of recreational fishing on biodiversity and fish resources through survey and monitoring	State Industry Community Traditional Owners Research NGOs	RCT18	1A

Management Action Targets		Geographic Focus	Management Actions	Potential Partner Groups	Links to RCTs	Priority
On-ground Actions						
9 	**S17.** By 2007, implement a marine water quality management program.	Regional	• Implement management programs targeting the protection of water quality in areas of high biodiversity value and threat such as Marine Protected Areas • Complete Pilbara Water Quality Project and expand process to other priority areas • Waste management strategies are developed and implemented for the management of visitor waste management at tourism nodes along the Rangelands Coast • Construct necessary infrastructure to minimise the impacts of waste (e.g. sewage, grey water and catchment nutrient and sediment loading) on marine environments • Marine waste disposal and management facilities are constructed at all highly used areas in particular, moorings, boat ramps, marinas, jetties • Support industry in preventing and mitigating impacts of dredging activities on environmental water quality • Support regional, state and national initiatives for the reduction of marine debris"	State Industry Community Traditional Owners Research NGOs	RCT17 RCT16 RCT18 RCT19 RCT1 RCT2 RCT3	3A
12 	**S18.** By 2008, implement management strategies identified in 3 marine protected area and terrestrial protected area management plans	Priority areas	• Implement priority actions for coastal protected areas and encourage an integrated marine and coastal management approach across the region • Engage community in the management of protected areas through the provision of opportunities for community stewardship and community driven projects • Implement frameworks to protect wildlife from the current and potential impacts of wildlife tourism	State Industry Community Traditional Owners Research NGOs	RCT18 RCT20 RCT1	1A
10 	**S19.** By 2008, implement sustainable management practices for recreational fishing across 5 target species.	Priority areas	• Continue to take an adaptive management approach to prevent the over-exploitation of fish stocks • Examine and trial a combination of gear restrictions, bag limits, tagging methods and recreational fishing licences to reduce fishing pressure in highly valued fishing areas • Encourage best practice to minimise the impacts of recreational fisheries • Develop ESD plans for priority recreational species • Support industry and community initiative to increase the sustainability of recreational fishing on target species and biodiversity •	State Industry Community Traditional Owners Research NGOs	RCT18 RCT1 RCT2	1A

Management Action Targets		Geographic Focus	Management Actions	Potential Partner Groups	Links to RCTs	Priority
9 	**S20.** Significantly improve conservation status of 30% of significant species and ecological communities by 2010	Priority Areas	• Recovery Plans for all marine threatened species in the Rangelands are developed • Implementation of Recovery Plans for threatened species and threatened ecological communities on a priority basis • Conduct research into priority flora and fauna to determine status • Implement a study on the status of threatened species of national significance on offshore islands • Protect the refuge value of coastal islands through implementing threat abatement programs and continued biodiversity conservation actions • Make necessary nominations for addition to threatened list • Implement threat abatement plans • Protect and/or recover threatened species on island refuges • Identify islands and species suitable for establishing refuge populations • Continue baiting and predator control programs to prevent feral pest incursions • Manage and control human impacts to biodiversity on islands including industry, recreation and tourism impacts • Support the development or review of new or existing recovery plans • Implement recovery plans on a priority basis	State Industry Community Traditional Owners Research NGOs	RCT18	1B
9 	**S21.** By 2010, coordinated programs are in place to detect, monitor and control invasive species in all priority marine, coastal and island environments	Priority Areas	• Determine priority areas for invasive species management • Develop a staged works program for control and eradication • Educate community and stakeholders of impacts and control of invasive species • Develop an ongoing program to monitor for invasive species • Continue to Implement the National Ballast Water Policy and Marine Pest Incursion Strategy • Implement programs for the detection and control of marine invasive species • Identify current marine and coastal invasive species and pests in marine and coastal waters • Adopt marine incursion protocols • Identify marine and coastal invasive pests with the potential to establish and implement necessary mitigation measures • Invasive species control on islands used as refuge	State Industry Community Traditional Owners Research NGOs	RCT18	3A

Management Action Targets		Geographic Focus	Management Actions	Potential Partner Groups	Links to RCTs	Priority
Institutional Frameworks, Planning and Policy						
12 	**S22.** Develop 3 management plans, which include frameworks and initiatives to improve biodiversity conservation in priority coastal and marine areas of the Rangelands by 2010	Regional	• Develop marine and coastal protected area management plans • Make recommendations for inclusion in CAR system • Support the implementation of Regional Marine Planning (RMP) in the Rangelands • Identify areas for assessment for management and develop and adopt management plans for areas selected • Support the development of local authority coastal management plans • Ensure that marine biodiversity values in all IMCRA regions is adequately represented in formal reserve systems • Support and manage existing, and the development of new fish habitat protection areas • Support the application of EPA guidance for marine habitat protection • Marine water quality data of prioritised areas and data collated from North West Shelf Joint Environmental Management Study available for marine planning and management purposes	State Industry Community Traditional Owners Research NGOs	RCT18 RCT19 RCT20	1A
10 	**S23.** By 2007 all commercial fisheries are operating within the principles of ecosystem based management and integrated fisheries management	Regional	• Use benchmarks identified in ESD plans to continue to monitor the ecological sustainability of commercial fisheries • Develop ESD plans for all fisheries • Identify external impacts to commercial fisheries and develop management strategies to address risks/impacts • Commission a study to determine areas of current and potential habitat loss to commercial fisheries with a focus on reclamation, modification, dredging, mining, bottom trawling activities	State Industry Community Traditional Owners Research NGOs	RCT1 RCT18 RCT19 RCT16	1A
12 	**S24.** Protection of offshore atolls by cooperating with International parties by 2008	Regional	• Review current statue of shark stocks • Liaise with Indonesian Government on current issues including improved protection for fauna such as sharks, Turtles, trochus and Beche de Mer • Develop policies to respond to issues	State Federal Industry Community Traditional Owners Research NGOs	RCT18	1C

Management Action Targets		Geographic Focus	Management Actions	Potential Partner Groups	Links to RCTs	Priority
Education, Awareness and Further Engagement						
11 	**S25.** By 2006, develop a develop a communication strategy targeting recreational fishers and tourists to promote ecologically sustainable management of the marine and coastal resources and biodiversity	Priority Areas	• Identify education needs for groups (community, schools, industry and agency) • Develop programs to meet needs of groups • Implement programs including the development of communication material • Initiate training and education of Volunteer Fisheries Liaison Officers and other similar programs • Promote integrated fisheries management approaches • Foster the uptake of ecologically sustainable practices by all stakeholders	State Industry Community Traditional Owners Research NGOs	RCT18 RCT19 RCT20	1B
12 	**S26.** Support Improved protection/ management of the Ramsar and World Heritage listed sites and other areas of national or international significance by 2006	Site Specific	• Identify and assess need for management planning for the establishment of a MPA at Ramsar listed sites • Management planning involving the community • Continued implementation of Shark Bay World Heritage Strategy • Continued support for the protection of world heritage values	State Industry Community Traditional Owners Research NGOs	RCT18	1C
	See MAT L17					
Cultural Heritage						
	See MATs L18, L19 L21					

SECTION III - THE ORD NAP REGION

3.1 Introduction

The Ord River is the second largest river in Western Australia and one of the most well known in the country (Table 15). Its catchment area, the Ord River Basin, has been identified as a priority catchment under the National Action Plan for Salinity and Water Quality (NAP).

The NAP is the first plan of its kind and tackles two major NRM issues facing Australia's rural industries, regional communities and our unique environment. It targets 21 priority regions throughout Australia affected by salinity and water quality problems, with its goals being to motivate and enable regional communities to use coordinated and targeted action to:

- prevent, stabilise and reverse trends in salinity, particularly dryland salinity, affecting the sustainability of production, the conservation of biological diversity and the viability of our infrastructure
- improve water quality and secure reliable allocations for human uses, industry and the environment.

Table 15 Ord River Catchment Statistics

Length	588 kilometres
Catchment area	53,500 square kilometres
Source	Mt Bedford (95 km NNW halls creek)
End	Cambridge Gulf
Rainfall	500-800 millimetres
*Mean wet season flow	2,640 gigalitres

*The wet season flow of the Ord River varies dramatically from year to year.

Whilst many of the environmental and social pressures in the Ord Catchment are essentially the same as for other areas of the Rangelands, it has unique challenges derived from damming the river for current and proposed irrigation development. Water quality and supply are the biggest issues in the Ord and for this reason it has been identified as a priority catchment.

During the early 1960s the Kununurra Diversion Dam was built as the first stage for developing a broadscale irrigated agriculture industry in the Ord River Valley. This resulted in in the formation of Lake Kununurra and the town of Kununurra and the farms of the Ord River Irrigation Area (ORIA) grew up around it. In the early 1970s the Ord River Dam (ORD) was built to provide a more reliable supply of water for the irrigation areas. Lake Argyle, formed by the construction of the Dam, is the largest man-made water body in Australia. Its volume when full is approximately 10,700 gigalitres, or roughly 15 times the combined volume of all of Perth's water supply dams. The Lake covers an area of 945 square kilometres. Since 1996 a hydropower facility has operated at the Dam supplying power to Kununurra, Wyndham and the Argyle Diamond Mine.

The regulation of flow on the Ord River has had a major impact on the hydrology, ecology, and spiritual and cultural values of the river. As well as the land behind dam walls being permanently flooded, the variability of river flow downstream has been altered, with a reduction in high flows and an increase in low flows. High evaporation rates, withdrawals for irrigation and seepage losses significantly reduce the River's total annual flow.

The major tributaries of the Ord River upstream of Lake Argyle are the Elvire, Panton, Nicholson, Negri, Wilson/ Bow and Behn Rivers. The Dunham River is the largest tributary downstream of Lake Kununurra. The Ord River drains into the West Arm of Cambridge Gulf. Nearby rivers include the Keep and King.

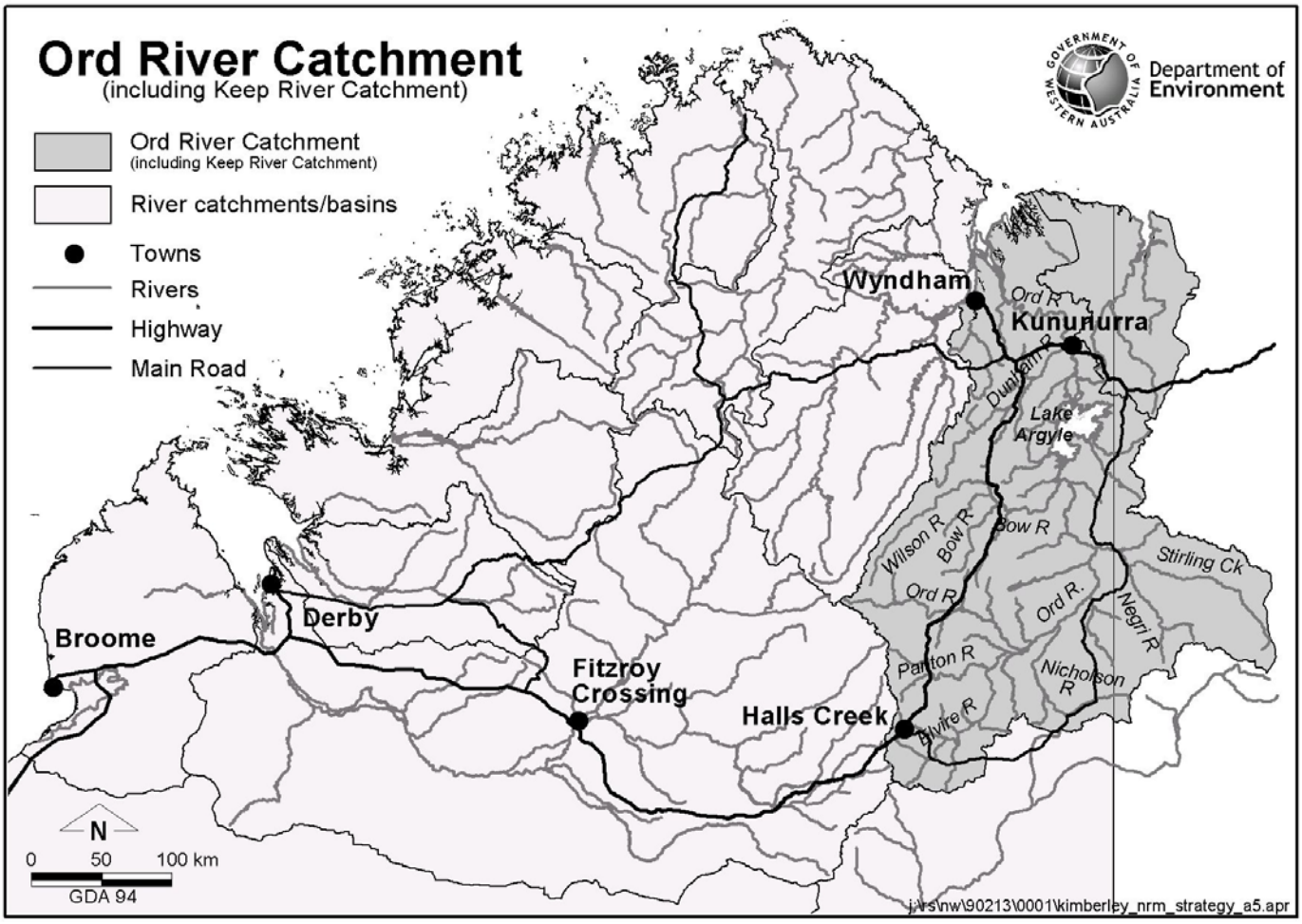


Figure 16 Ord River and Keep River Catchments

The Ord River Catchment (Figure) occupies over 53,500 square kilometres of the east Kimberley. Its upper catchment straddles the Halls Creek Fault and is composed of basalts, sandstones, mudstones and minor limestone. The course of the main channel is somewhat confined by bedrock outcrop and meanders through broad open valleys. It varies from a wide channel with large sand and gravel bars that are very lightly vegetated, to channels filled by well-vegetated longitudinal bars. A natural gorge in the Carr Boyd Ranges hosts the Ord River Dam. Below the dam, steep-sided tablelands and rocky hills border wide plains of deep cracking clay soils. Downstream of Kununurra the channel is characterised by lateral bar forms and heavy growth of algae and macrophytes, the latter a result of the changed flow regime and nutrient levels since Dam construction. In its estuarine reaches the Ord exhibits large sediment accumulations regularly spaced between meander bends. Gully erosion is common along the flat flanks of the River.

Climatic conditions have a substantial influence on the lifestyle, economy and environment within the Catchment. It has a tropical monsoon climate with two distinct seasons separated by short transitional periods. Hot and humid conditions characterise the “wet season” from November to April, when the region receives 90 percent of its annual rainfall. From May to October south easterly airflows bring the “dry season” typified by low humidity and moderate temperatures. Most rivers and creeks in the Basin are seasonal with flows between November and April.

The Ord River plays an important part in the life of many east Kimberley residents and visitors. Recreational activities centred on the River include fishing, sightseeing and camping. Thirteen thousand hectares of sugar cane, horticultural produce and other crops are irrigated with water from the Ord, and these industries together with tourism, mining and pastoralism, support the town of Kununurra.

3.2 The Assets of the Ord

The Ord River, with its tributaries the Dunham, Panton, Nicholson, Wilson/ Bow, and Negri Rivers, produces the second largest flow volume in Western Australia. Regulation by the two dams allows water collected during the wet season to be released throughout the year.

Kimberley rivers serve many ecological and human needs. The vegetation they support provides habitat for fish, birds and many other animals. New ecosystems have evolved with the changes in channel form, water balance and vegetation since the Ord River was dammed. The Ord is an important habitat for birds, with more than 75 species recorded including significant breeding and migrant populations.

The Ord River and its tributaries are used for crop irrigation, power generation, fishing and aquaculture, tourism, scientific research, and as wilderness destinations. They also hold great cultural and spiritual significance, especially for Traditional Owners. Many significant anthropological and archaeological sites are associated with waterways. The Indigenous community has a much greater dependence on the environment and the disturbance that has occurred in the past 100 years has impacted significantly on long established means of food harvest and cultural traditions. This has contributed in part to a breakdown in their social order with resulting social impacts spread throughout the community.

The construction of the ORD changed the River's hydrology significantly. The River's environment downstream of the ORD has become more like a wet tropics river than one in the dry tropics. The fluvial features and fringing vegetation of the River have changed significantly. Lakes Kununurra and Argyle and the lower Ord Floodplain have been listed as wetlands of national significance under the Ramsar Convention, as they provide refugia that compensate for the loss of seasonal wetlands elsewhere and for maintaining biological diversity in the region.

The Ord River is prone to serious flooding due to tropical lows, cyclones and extreme thunderstorm activity. The largest recorded flow on the Ord River, ~30 800 m^3/sec, was observed in February 1956 near the site of the present-day dam wall at Lake Argyle. Other major floods on the Ord River occurred in 1959, 1960, 1966, 1971, 1980, 1993 and 2001. The highest recorded storage level in the ORD was in March 2001. The two dams on the Ord River have greatly diminished the flood flows in the lower Ord, and floodwaters are now discharged over several months. The combined flow through the regulation valves at the Ord River Dam and spillway has rarely exceeded 1,000 m3s-1 since the Dam's construction in the early 1970s, despite estimated flows into it of more than 10,000 m3s-1. In March 2001 the flows released (spillway and regulation valves) were about 1,200 m3s-1. Flood flows downstream of the Kununurra Diversion Dam are now dominated by the flows from the Dunham River, despite its catchment area being less than 10 percent of the Ord's.

With the storage effect (Lake Argyle) of the ORD between the upper and lower catchments, the town of Kununurra has a low risk of being directly affected by flooding. Although river crossings have been progressively upgraded, the road connecting Kununurra and Wyndham (Victoria Highway) with Halls Creek (Great Northern Highway) can be cut by floodwaters in the upper catchment for days at a time. The change to the flooding regime on the lower Ord River has caused positive and negative changes to river and floodplain flora and fauna, which are being investigated by scientists.

Designed in the late 1950s, the irrigation system was constructed to take advantage of what, at the time, was thought to be abundant supplies of water to flush the system, ensuring no build up of farming residues within the Irrigation Area. A network of channels feed the Irrigation Area's clay soils of the Kununurra series. Areas between the main plain and River are sandier soils of the levee bank and the Pago and Cockatoo sands between the plain and nearby hill system.

3.3 Major Uses and Value of the Ord Catchment

The predominant industries within the Catchment are mining, cattle production and irrigated agriculture. The largely undeveloped environment is also a focal point for tourism, recreation and an important source of food and focus for cultural traditions of Indigenous people. The population of the two Shires

that make up the catchment is 11,176 with approximately 50 percent being Aboriginal people (Bureau of Statistics, 2001). Most of the population is centred in the towns of Halls Creek, Kununurra, Warmun and Wyndham. Much of the 53,500 square kilometres of the Catchment comprises pastoral stations and Indigenous communities that support small, isolated populations.

Agriculture

The main irrigated area is in the ORIA surrounding Kununurra. The Irrigated Area increased from 1,865 hectares in 1978 to 4,407 hectares in 1990 to the current potential of the ORIA of approximately 13,000 hectares. Horticulture remains the predominant industry for farmers in the ORIA, with average annual growth in production value between 1982 and 2000 above 21.4 percent (Department of Agriculture, 2003). Crops include mangoes, sugar, cucurbits, vegetables, field crops, leucaena, hybrid seed crops and sandalwood/ tropical forestry, with an estimated value in 2002/ 2003 of $53 million.

Ord River Irrigation Area (ORIA) Stage 1

The ORIA delivery system was built and largely completed in the early 1960s with the Ord Dam and the filling of Lake Argyle completed in 1972. The system was designed around a furrow irrigation system, gravity fed from Lake Kununurra. At the time this system was considered ideal based on the flat topography and predominantly heavy clay soils.

The annual average water allocation to ORIA Stage 1 is 335 gigalitres. Water is delivered through a series of channels to supply points situated on the boundaries of properties. Water is then provided to properties through a further series of channels that deliver water directly to crops through siphons. On almost all blocks the water flow down the furrow exceeds its lateral movement across the soil surface and into the profile. As a consequence there is a flow of water off-farm prior to adequate soil moisture levels being achieved. Excess supply and irrigation water drains from the area and returns to different parts of the river.

Water is allocated to users that take water from the River. This includes the Ord Irrigations Co-operative (OIC), which provides water to its members in the channel system supply area and self suppliers along the River.

Water use improvements are being planned and implemented within the channel system supply area. The actions and initiatives related to this area are guided by the Ord Land and Water Plan and requirements from regulation.

Mining

Mining in the Catchment commenced soon after the discovery of gold near Halls Creek in 1882. Currently diamonds are the main mineral commodity extracted from the area with most production coming from the Argyle Diamond Mine south of Lake Argyle. Alluvial diamonds are also produced at Smoke Creek and Bow River and there is potential for further diamond discoveries in the old river channels of the Ord River. Nickel and copper production commenced at the Sally Malay Mine in September 2004 and there is significant nickel-copper mineralization at the nearby Copernicus prospect. Lead and zinc deposits are present at Shangri-La and Sorby Hills.

Tourism

The Ord Catchment is regularly marketed as a part of Australia's last great wilderness with its rugged ranges, rivers and estuaries presenting a mix of isolation and highly valued landscapes. Damming the Ord River developed vast waterways that wind through distinctive gorges and provide a wide variety of recreational and sporting opportunities. The area is now also a haven for a variety of birds and other wildlife, much of which is registered as a Ramsar site. Purnululu National Park, a World Heritage area renowned for its striking sandstone domes formed about 360 million years ago has also become a prime destination for visitors around the world.

Pastoral Industry

The pastoral industry was established in the Ord in the 1880s. There are currently 23 pastoral stations in the Catchment, making pastoralism the dominant land use. Ownership of leases is mixed, with large corporate enterprises dominating production, and there are six leases controlled by Indigenous interests. There are few permanent station employees, with additional staff being employed during the dry season, mainly to assist with mustering and yard work. Helicopters are widely used for mustering.

The number of cattle turned off in 2002/ 2003 from the east Kimberley was about 60,000 head, valued at $45 million. Most cattle are turned off as young animals up to 30 months of age and exported live through the port of Wyndham to Indonesia, Malaysia and the Middle East.

Cattle enterprises are based on very large pastoral leases (typically > 150,000 hectares), relying mainly on native pastures. The quality of feed available from native pastures falls to low levels during the dry season and some protein supplementation is carried out to reduce the loss of condition, particularly in lactating cows. Paddocks are very large encompassing varying land types, which can lead to uneven grazing and over-use of favoured areas that are within reach of water. Conseqnuently, resting is sometimes required to allow pasture recovery. On most leases there is a mixture of artificial water sources (dams, bores) and natural waters (rivers, springs and lagoons), some of which are ephemeral.

Ord River Regeneration Reserve

As mentioned above, grazing has been the predominant land use in the Ord Catchment since European settlement in the 1880s. Initially stock control was limited and due to the small number of artificial watering points, domestic and non-domestic animals concentrated themselves around natural watering points. Various studies and reports from 1944 onward indicated widespread vegetation degradation and erosion, in particular along stream banks. This was especially apparent in one major group of soils prone to wind and water erosion when vegetation cover declined.

To protect the storage capacity of the proposed Lake Argyle and investment of the newly formed ORIA, a catchment stabilisation program was initiated in the mid-1960s in an area later to be known as the Ord River Regeneration Reserve. Stock were removed from approximately one million hectares and regeneration work was undertaken by the Western Australia and Northern Territory Governments.

During the early 1990s as part of a Kimberley-wide program, the Ord Catchment was assessed for range condition on a pastoral lease/ land system basis. Four land systems that included the Reserve were assessed with 50 percent or more of their area in “poor” condition, or around 12 percent of the Catchment.

Furthermore, in the period up to 1985 the Water Authority of Western Australia measured the volume of sediment accumulated in Lake Argyle. From this work and the measurement of sediment levels in river flows prior to dam construction it was predicted that the storage volume of the Lake would be reduced by one third by 2070. Additional studies in 1993 identified the Regeneration Reserve as still the major source of sediment into Lake Argyle and that reservoir storage volumes below the spillway level had been reduced by six percent in twenty years. However, studies also suggest that sediment flows into the Lake may have been reduced since 1987.

In the most recent review of the Reserve in 2001, one of seven recommendations was:

- that the cross sections of Lake Argyle surveyed during the previous review (1990/ 1992) be repeated as soon as possible and at regular subsequent intervals to provide information about the levels of sediment build-up in Lake Argyle.

Current work on the Reserve is limited to monitoring rangeland condition by the Department of Agriculture.

Indigenous Values and Uses

Aboriginal people hold strong cultural ties and values to the Ord River and its environment. The River is an integral part of Aboriginal life and culture and changes to the River have resulted in changes to their lifestyle. The River is also an important source of food and water and many sites along its banks are integral to local Aboriginal culture. Fish and turtle were a significant food source and are still much sought after today. Because of their close connection with this area, Traditional Owners are working with others to preserve and care for its resources so they can be enjoyed by everyone (Information supplied by Mirima Dawang Woorlab-gerring Language and Culture Centre).

As traditional custodians of the land, Aboriginal people want to be directly involved in its management. They have a wealth of traditional knowledge about the environment in the ORIA and this knowledge should be an integral part of land management.

3.4 Major Threats to the Ord

Current environmental challenges within the Ord Catchment, in addition to those relating to changed hydrology from the dams, include:

- rising groundwater and salinity;
- decreased water quality (nutrients, chemicals and sediments returned to the Ord River via the drains);
- changed water regimes;
- weeds and introduced feral animals; and
- declining air quality from sugarcane fires and chemical spraying (WRM 2003, unpublished).

Salinity and Water Quality

The ORD, Kununurra Diversion Dam (KDD) and construction of the M1 channel have resulted in rising groundwater levels and changed flow (Salama *et al*., 2002), and the resultatnt salinity is a threat to the area. Saline areas have already been identified in the Packsaddle area and other areas are also expected to experience this (Salama *et al*., 2002).

The average annual sediment load downstream of the Diversion Dam has changed from 24Mt pre-dams to 0.6Mt post-dams. Of the 0.6Mt, approximately 0.015Mt comes from Lake Argyle, the rest from the Dunham River (Rodgers *et al*., 2000). Since the completion of the dams, sediment in Lake Argyle has been deposited at a rate of 24 million m3/yr. This sediment deposition effectively reduces the useable storage by 600 million m3, a little over 10 percent of the original volume of the dam (Doupé and Pettit 2002; Water and Rivers Commission, 1997; 1998).

The sensitivity of fish populations to irrigation practices in the Ord is highlighted by occasional fish deaths near irrigation drains, strongly implicating pesticides as the cause (mainly DDT in the 1960s and 1970s, and Endosulfan in 1997) (OBP 2001, Doupé *et al*., 1998). Studies have also shown that irrigation increases the loads of phosphorus and total oxidized nitrogen going into the Ord River, and increased concentrations of nutrients (Lund and McCrea, 2001, Doupé *et al*., 1998). Furthermore as land is released for more irrigation, rights to use water from the Ord River will increase the amount of water allocated from the River.

Altered Flow Regimes

Changed flow dynamics have resulted in significant changes in geomorphology for the Ord River (Doupé and Pettit 2002, Trayler *et al*., 2002, Wolanski *et al*., 2001, Water and Rivers Commission 1998, Water and Rivers Commission, 1997). An altered hydrological regime in the Ord River has resulted in a significant reduction of floodplain inundation frequency and extent (Water and Rivers Commission, 2003)

impacting on the health of the ecosystem through the inability to widely disperse seeds and juvenile aquatic fauna. Sediment build-up and associated vegetation colonisation has resulted from cessation of regular flood events (Water and Rivers Commission, 1997) resulting in a decrease in channel capacity, in stream habitat area and diversity (Trayler *et al*., 2002).

Damming the Ord River has restricted certain species from following their usual migration path, such as the barramundi and freshwater crayfish (Cherabun) (OBP, 2002). This causes genetic isolation, restricted access to breeding waters and in extreme droughts, the localised loss of species in a reach upstream from a migratory barrier (Storey *et al*., 2001). Damming the Ord River is also thought to have resulted in a loss of habitat and reduction in some fish and other species (WRM 2003, unpublished).

Fire

The control of the fire regime is a major concern for managers, with wildfires posing a serious risk to feed reserves between about May and December each year, when almost no rain falls and the grassy fuel is dry and easily ignited. Because of the rugged terrain and limited ground access across much of the region, aerial control burning is used by fire authorities to install strategic lines or firebreaks, soon after the end of each wet season. Planned burning is used beneficially on some stations to rejuvenate pastures and to control woody vegetation.

Weeds and Feral Animals

Control of feral animals (especially donkeys) and weeds is an important aspect of land management. A comprehensive program to eradicate donkeys from pastoral areas is at an advanced stage. Where weeds are concerned, the limited resources available for control are directed mainly at a relatively few species of declared weeds that can cause serious economic losses if uncontrolled. There are a number of other weeds of concern that have potentially serious environmental effects, particularly in riparian situations.

Potential weed, insect, disease and animal threats include:

- **Weeds** - Parthenium (WONS), Mimosa Pigra (this weed has the potential to choke all waterways), Leucaena (environmental weed) Cabomoba caroliniana (currently in the Northern Territory and would choke out all water courses);
- **Vertebrates** - Cane Toads (threaten biodiversity and obstruction of irrigation systems), Sparrows (attack grain crops, and out compete native birds), Cats (threaten species diversity);
- **Disease** - Citrus canker (effect viability of trees and market accessibility), Citrus greening (bacterial disease that causes trees to die, currently in Indonesia); and
- **Insects** - Exotic fruit fly (maggots in fruit, impacts on market access), mango pulp weevil (makes fruit unsaleable, impact on international markets).

3.5 Current Management in the Ord

Considering the changes the Ord River has been subjected to since its damming, there is relatively little information available on subsequent impacts. Most studies conducted on the changes to groundwater, water quality, vegetation, river channel morphology and river flow dynamics have only been occurring since the late 1990s. However, several projects have been undertaken in recent years to collect and monitor data from the Ord River.

Ord Water Quality Program

This Program is undertaken in partnership with the Department of Environment and the Ord Irrigation Cooperative (OIC). Water Quality data is collected on a monthly basis from about 11 sites, five of which are on the Ord River and six in supply and drainage channels of the Irrigation Area. Parameters being monitored include nutrients, salinity, total suspended solids (sediment), water depth and physical

parameters such as pH, dissolved oxygen, temperature and conductivity. Approximately 30 different types of pesticides are also monitored.

The Program commenced in response to a substantial fish kill in 1997 and it appears that farming practices have changed since then to reduce the risk of a similar event. This has led to an improvement in the quality of the water during the past seven years, which is confirmed by monitoring results.

Ord Catchment Hydrology

The Ord River Catchment is also monitored by Department of Environment, to improve understanding of catchment hydrology for water yields, storage, water release, allocation and environmental flows. A network of hydrometric sites such as gauging stations, and rainfall and dam storage monitoring stations are used to collect data for water resource planning and management.

Irrigation Area Groundwater Project

This Project aims to obtain a better understanding of the interactions between groundwater and surface water in the ORIA. The information will be used to develop management strategies to combat rising groundwater and salinity issues. It has been led by a CSIRO research team, funded originally by the Ord Bonaparte Program (OBP). Since the OBP ceased in December 2003, the Project has continued with funding from the NAP.

Groundwater bores and surface water monitoring stations are located throughout the ORIA collecting data on drainage flows, salinity, surface water, and groundwater depth. The information is being used to develop predictive models of the groundwater responses to different management actions.

Ord River Catchment – Water Quality Monitoring Information

Nutrient concentrations in the lower Ord River reaches below the Diversion Dam have been relatively constant during the past six years since sampling commenced by the Department of Environment (Department of Environment, 2004). Nutrient concentrations, namely nitrogen and phosphorous, generally increase between the upstream (un-affected by irrigation) to the downstream sites (irrigation affected). Downstream sites are affected by nutrient inputs from irrigation drainage outfall, the Dunham River and a variety of small creeks.

The Australian and New Zealand guidelines for fresh and marine water quality (ANZECC, 2002) provide trigger values for nutrients in tropical Australian highland and lowland river systems, including northern Queensland, Northern Territory and north-west Western Australia. The ANZECC guidelines acknowledge that if locally relevant guidelines have been developed, they should be used in preference to the ANZECC guidelines. Due to changes and difference in nutrient levels from upstream to downstream of the Ord River, one of the actions proposed in the strategy is to develop locally relevant guidelines.

The Lower Ord and Estuary Project

This Project was designed to improve understanding of the status and function of the Lower Ord River and estuary, and its response to changes in flows and loads of sediments and nutrients from the Catchment. The data collected by the Department of Environment will enable comparative projects to be undertaken in the future to understand how the River has changed over time.

Data were collected on a monthly basis over a two-and-a-half year period. Two intensive field surveys were conducted within this period to capture both wet and dry season flows. The Project continues on a scaled down basis, involving the collection of data approximately every three months.

Monitoring stations for the Project are generally evenly spaced from Mambi Island to the mouth of the Lower Ord River. The types of parameters being monitored in the Project include water quality,

nutrients, salinity, total suspended solids (sediment), water depth and physical parameters such as pH, dissolved oxygen, temperature, conductivity, chlorophyll A (algae) and organic carbon.

Data were analysed and any trends described mathematically. Predictive models have been developed from the trends. A final report has been developed; "The Response of the Lower Ord River and Estuary to Management of Catchment Flows and Sediment Nutrient Loads".

Ecological Risk Assessment Associated with the Impact of Irrigation Return on Biodiversity in the Lower Ord River

This Project was one of three case studies of irrigation areas [(Gouldburn-Broken (Vic), Ord (WA) and Fitzroy (Qld)] to identify the key ecological issues, assess knowledge needs for each issue and key knowledge gaps, and identify what needs to be investigated to address these knowledge gaps. The study provided details for the development of a framework to assess the ecological risks associated with irrigation systems in Australia.

It was funded by Land and Water Australia as part of the National Program of Irrigation Research and Development and is no longer operational. Phase two of the project was to better assess the nutrient and sediment loads from the catchment land systems and effect on the Lower Ord River ecosystem. Two flow events were monitored, however, logistical and funding issues for the second phase prevented the project continuing.

Environmental Flows Initiative

This Project was aimed at studying the ecological characteristics of the Ord River and other nearby unregulated river systems to define ecological water requirements and assist in setting environmental water provisions for the Ord Catchment. The study was set up by the Department of Environment in response to the proposed expansion of the Irrigation Area (Ord Stage Two).

Ramsar Site Monitoring Project

During 2005, the two Ramsar sites in the East Kimberley, Lakes Argyle and Kununurra, and the Lower Ord Estuary Floodplain, will be subject to a monitoring project undertaken by CALM. The Project will provide a "snapshot" of the current status of the Ramsar sites and the information will be compared to other data that was collected in 1988 and 1998.

Planning Tools in the Ord Catchment

Ord Land and Water Management Plan 2000

The Ord Land and Water Management Plan (OLWMP) 2000 is the outcome of a four year community process to address a wide range of environmental issues. It established goals to address:

- sustainability of the Irrigation Area through a "Land" component;
- healthy river systems through a "Water" component;
- sustainable native ecosystems through a "Conservation" component; and
- environmentally responsible community through a "Town" component.

Development of the Plan was conducted in a number of stages, from an initial information and communication phase, identification of management issues and setting of goals, through to the implementing recommendations. The Ord Land and Water Board, which comprises local people, was established to over see implementation of the Plan.

With the release of the OLWMP came a commitment from industry and the community to protect, maintain and manage the Ord Catchment environment. Goals addressing this intent are to:

- improve irrigation management to achieve 65 percent average annual water use efficiency on all irrigation farms within five years.
- improve irrigation infrastructure and management to achieve a water delivery efficiency of 75 percent within five years.
- reduce the load of chemical contamination in tailwater by 40 percent within five years.
- reduce the load of nutrient contamination in tailwater by 40 percent within five years.
- reduce sediment loads in tailwater by 40 percent within five years.
- reduce ground water levels to below two metres from the surface across the whole irrigation area within five years while preventing any new areas from rising above that level.
- hold the quality of ground water at or above the high quality present in 2000.
- prevent further damage and modification to the natural riparian vegetation.
- develop a plan to allocate water from the Ord River for the environment and other uses .
- develop the plan with full community involvement within five years.
- reduce the off farm exports of chemical nutrients and soil into the Dunham River during the dry season by 50 percent within five years.
- within ten years develop a full catchment plan for the Dunham River that involves all the stakeholders.

Commitment to achieving these goals is demonstrated by outcomes already achieved through implementation of the Plan. The Plan also outlines a range of other goals addressing fire management, protection of riparian vegetation and ecology, groundwater management, salinity and water quality.

Management Arrangements in the Ord Catchment

The Ord Reference Group was put together through an OIC and OLW initiative as a means to achieve the water quality, efficiency, availability and ground water targets as set and prioritised in the OLWMP and the Water Use Improvement Program (WUIP). The formation of the Group in September 2003 was the result of several years of work and relationship building between the industry, community and government member organisations.

The rationale behind the Group's formation was to integrate past, current and proposed "water" projects into a Water Management Program. This would identify gaps, remove duplication and ensure an aligned effort with respect to improvements in water management. It would allow community, industry, research and government needs to be met in both a NRM and a regulatory context.

The intent of the Group is to broaden its membership and sphere of operations with respect to water management outward from the ORIA into a catchment scale.

Management Options

Environmental Management Systems (EMS) provides a framework for whole farm management systems. EMS can provide best management guidelines for nutrient management plans, best management guidelines for chemical use, water use efficiency and soil management.

EMS can be used as a tool by land managers for monitoring the environmental impacts of horticulture on land, water and biodiversity and provides guide to work towards best management.

Prioritisation Process

Section IV outlines the prioritisation process undertaken by all sub-regions in the Rangelands. As it was anticipated that the Ord Catchment would have some different priorities to the rest of the Rangelands, due to the focus on salinity and declining water quality, the process was undertaken by the Ord Catchment Reference Group specific for the Ord Catchment.

The ranked issues for the Ord Catchment are provided in Table.

Table 16: Ranked Key NRM Issues for the Ord

KEY NRM ISSUE	Mean Weighted Whole-of-Rangelands Score	Tier
Land Primary Productivity Sustainability	45.0	1
Native Vegetation Integrity	44.3	1
Water Quality/ Supply	41.3	1
Declining Soil Condition	39.8	1
Capacity for NRM	39.0	1
Planning for NRM	36.8	2
Heritage/ Culture	36.8	2
Inland Water Quality	33.0	2
Altered Water Regimes	30.8	2
Terrestrial Native Species and Communities Integrity	26.3	2
Aquatic Native Species and Communities Integrity	26.3	2
Marine Ecosystems Integrity	16.5	3
Air Quality	15.0	3
Marine Native Species and Communities Integrity	14.3	3

In general the ranking is similar to that of the whole region, except for the ranking of water quality/ supply and land primary productivity sustainability. The above tiers are reflected in the ranking of the MATs for the Ord Catchment. The process for the prioritisation of MATs in the Ord Catchment was done in line with the whole of Rangelands region.

Understanding Priorities for the Ord Catchment

High priority MATs for the Ord can be summarised as follows:

- continued implementation of the community-driven Ord Land and Water Management Plan and Water Use Improvement Plan;
- identification of salinity risk areas;
- groundwater management; and
- integrated catchment management.

ORCT1: No new occurrences of salinity in the ORIA by 2014

ORCT2: A reduction of 10% in the area of salinity affected land in the ORIA by 2014

ORCT3: By 2025, Maintain or improve the condition of soil in the Ord Catchment as measured by an integrated index of existing soil attribute measures developed by 2008

ORCT4: Groundwater levels in the ORIA are to be maintained at/or below two metres by 2015

Management Action Targets		Geographic Focus	Actions	Potential Partner Groups	Links to RCTs	Priority
Benchmarking and Monitoring						
1 	**OL1.** Assess whole catchment for salinity risk areas by 2010	Ord Catchment and ORIA	• Catchment assessed and mapped for salinity risk • Identify priority areas for protection and remedial action based on salinity risk assessment • Mapping of soil permeability, to identify where irrigation practices are contributing to groundwater recharge	State Industry Community	ORCT1 ORCT2	1B
On-ground Actions						
10 	**OL2.** Best Management Practices for chemical use adopted by industry and implemented by 80% of users by 2008	ORIA	• Adoption of Best management guidelines in partnership with stakeholders	State Industry Community	ORCT3	1A
1	**OL3.** Priority actions implemented as outlined in the Ord Land and Water Management Plan 2000 with a primary emphasis on actions that address the causes of salinity by 2007	Ord Catchment	• Priority actions in the Ord Land and Water Plan implemented	State Industry Community	ORCT3 ORCT4	1A

Management Action Targets		Geographic Focus	Actions	Potential Partner Groups	Links to RCTs	Priority
						
1 	**OL4.** Trial remediation salinity strategies from across Australia by 2007	Ord Catchment	• Identify remediation salinity strategies suitable for the Ord Catchment • Trials undertaken for different salinity management options • Adoption and implementation of successful salinity trials	State Industry Community	ORCT1 ORCT2	1B
1 	**OL5.** 70% of landholders are utilising Property Management Plans to address sediment loading in run-off and salinity by 2010	Ord Catchment	• Best Practice Guidelines developed in partnership with stakeholders • Property Plans guided by BMPs • Monitoring of planned objectives • Land managers adopting salinity management actions • Develop management actions for saline sites or those at risk • Review salinity actions/strategies around Australia to ascertain recommendations/actions for saline sites • Adoption of whole farm plans • Set baseline levels and targets for salinity • Salinity management plans are adopted	State Industry Community	ORCT 1 ORCT 2 ORTC3 ORCT6	1A
5 	**OL6.** Develop and implement three groundwater management options/plans by 2007	ORIA	• Best practice for groundwater management options developed and implemented in partnership with stakeholders • Groundwater levels monitored and managed • Implement options for groundwater level management	State Industry Community	ORCT3 ORCT4	1B
Institutional Frameworks, Planning and Policy						
10 	**OL7.** By 2007 Environmental Assurance packages (EMS) are adopted by 80% of land mangers in the Ord River Irrigation Area	Ord Catchment	• Best Management Practice guidelines developed in partnership with stakeholders • Produce grown in the ORIA recognised for taste, quality and consistency in accordance with a certified Environmental Management System (EMS) program • 50% of produce grown in the Ord Valley in accordance with EMS accreditation • Best Management guidelines for nutrient and pesticide management developed	State Industry Community	ORCT1 ORCT2 ORCT3 ORCT4	1B

Management Action Targets		Geographic Focus	Actions	Potential Partner Groups	Links to RCTs	Priority
10 	**OL8.** By 2008 develop a Bio-security Protection Plan for the Kimberley Region	Ord Catchment	• Bio-security Protection Plan developed for the Kimberley region • Use the current Draft Bio-security Protection Plan for the Ord valley as a framework	State Industry Community	ORCT1 ORCT2 ORCT3	1B
Education, Awareness and Further Engagement						
11 	**OL9.** information and decision making tool kits are adopted by 50% of land mangers by 2008	Ord Catchment Priority Areas	• Four information and decision making Tool kit developed – soil pack, nutrient management, water use, waterlogging, drainage, bio-security	State Industry Community	ORCT3 RCT3 RCT1	1B
	See MAT L17					
Cultural and Heritage						
11 	**OL10.** Training and continued involvement provided to Aboriginal people for on-going environmental monitoring by 2008	Ord Catchment Priority Areas	• Environmental monitoring information will be comprehensible and readily obtainable • Aboriginal people to be actively involved in environmental monitoring programs • Cross cultural training programs undertaken to gain understanding of local Aboriginal culture and values	State Industry Community Traditional Owners	ORCT3 RCT3 RCT1	1B
	See MATs L18, L19 L21					

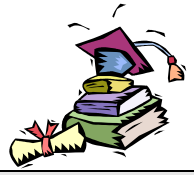
3.7 Ord Water RCTs and MATs

ORCT5: By 2025, Water Quality levels meet guidelines set by 2006 for Ord Catchment

ORCT6: Maintain storage volumes at current levels through reducing siltation levels contributed by the catchment, by 20 percent into Lake Argyle by 2024

ORCT7: River flows are sufficient to meet Environmental Water Requirements by 2010

Management Action Targets		Geographic Focus	Actions	Potential Partner Groups	Link to RCTs	Priority
Benchmarking and Monitoring						
3 	**OW1.** Water Quality Standards are developed specifically for the Ord Catchment by 2006	Ord Catchment	• Develop Total Phosphorus, Total Nitrogen, Electrical Conductivity and pH guidelines using information already collected for the Ord River • ANZECC water quality guidelines used as basis for forming standards • Monitor and assess pesticide and nutrient impacts on ecosystem function/process	State Industry Community NGOs	ORCT5	2B
4 	**OW2.** Establish baseline data to determine sediment loads and water volumes in Lake Argyle by 2010	Ord Catchment	• Develop knowledge and understanding similar to information already sought on the Ord • Improve the understanding of sediment loads and declining water volumes into Lake Argyle	State Industry Community	ORCT6 ORCT7	2B
On-ground Actions						
3 	**OW3.** Establish two demonstration farms to trial, develop and implement methods designed to reduce nutrients, pesticides and sediment in irrigation run-off by 2009	ORIA	• Trials undertaken • Report on success of trials developed • Trial methods to reduce nutrients and toxins from run-off eg. Nutrient traps	State Industry Community	ORCT5 ORCT4	2B

Management Action Targets		Geographic Focus	Actions	Potential Partner Groups	Link to RCTs	Priority
10 	**OW4.** Implement priority actions in the Water Use Improvement Program by 2010	Ord Catchment	• Implement the Water Use Improvement Plan	State Industry Community	ORCT5 ORCT4	1A
11 	**OW5.** Implement priority actions the Ord Land and Water Management Plan by 2010ing	Ord Catchment	• Implement priority actions in the Ord Land and Water Plan	State Industry Community	ORCT5 ORCT6 ORCT7 ORCT4 RCT1	1A
Institutional Frameworks, Planning and Policy						
12 	**OW6.** Develop Water Allocation Plans for all new developments from 2005	Ord Catchment	• From 2005 Water Allocation Plans are completed for water sources prior to development proposals • Reduce poorly planned development of water resources • Incorporate Aboriginal values and priorities for water resources	State Industry Community	ORCT5 ORCT6 ORCT7 ORCT4	1A
Education, Awareness and Further Engagement						
	See MAT L17					
Education, Awareness and Further Engagement						
	See MATs L18, L19 L21					

SECTION IV - NRM PRIORITISATION, INVESTMENT, MONITORING AND EVALUATION

4.1 Introduction

This Section describes how NRM prioritisation has occurred in the Rangelands, and highlights the emerging, priority actions possibly requiring investment in the Region. It also outlines the roles and responsibilities of potential investors in NRM in the Rangelands and some of the priority actions already being implemented in the Region resourced through the extension of NHT and the NAP.

It also highlights the principles that underpin investment planning in the Rangelands, and how these drove the development of the Rangelands NRM Investment Plan.

In addition, this Section describes how a monitoring and evaluation framework will be established to determine the effectiveness of investments in achieving the RCTs and MATs defined in the Strategy.

4.2 Roles and Responsibilities for Implementation

Implementation of NRM actions through strategic investment is the primary reason for developing the Rangelands NRM Strategy.

This will require development of strong partnerships between the community, government organisations and industry bodies, and a high level of coordination at Regional and sub-regional levels. Consequently it is worth broadly defining the roles and responsibilities of the relevant and likely partners in NRM investment in the Rangelands.

The Australian and State Governments

The Australian and State Governments provide leadership on NRM, administer relevant legislation and develop policy to support its implementation. They work jointly through a range of national forums, such as the Council of Australian Governments (COAG) and NRM Ministerial Council to ensure a coordinated approach to regional NRM planning and delivery so that it contributes to State and national outcomes. In particular they are working to develop frameworks for monitoring and evaluation to ensure investments through programs such as the extension of NHT and the NAP are effective and contribute to agreed targets, and ultimately improve resource condition.

The Australian and State Governments will continue to support the Rangelands NRM Co-ordinating Group establish systems for good governance and accountability to implement the Strategy, and continue to refine its targets to ensure on-going strategic investment in NRM.

The Rangelands NRM Co-ordinating Group and Sub-regional NRM Groups

Leadership for NRM in the Rangelands is the primary role of the Rangelands NRM Co-ordinating Group. To effectively undertake this role and inform the Group's decision making, it is advised by the:

- Kimberley NRM Group;
- Pilbara NRM Group;
- Gascoyne-Murchison NRM Council; and
- Goldfields-Nullarbor NRM Group.

The Co-ordinating Group will continue to work with the sub-regional groups to provide opportunities for on-going community input into the Strategy, and broker partnerships between government, community and industry organisations to implement NRM actions. It will also work jointly with stakeholders, and the Australian and State Governments to refine RCTs and MATs, which contribute to Regional, State and national outcomes.

The Co-ordinating Group, with advice from sub-regional NRM groups, will also have primary responsibility for overseeing processes to determine priorities and trade-offs for NRM investment in the Rangelands.

It is worth noting that to begin the process of regional NRM planning and delivery in the Rangelands, membership on the Co-ordinating Group (and sub-regional groups) has largely been via selection rather than election, and is consequently interim in nature. However, consistent with the requirements of the Bilateral Agreements on the extension of NHT and the NAP, the Rangelands NRM Co-ordinating Group is committed to moving toward democratic processes to determine its representativeness, membership, and decision making capabilities in the future.

Local Government

Local government has a very important role to play in regional delivery of NRM in the Rangelands. It can assist by ensuring that Regional priorities are reflected in local Town Planning Schemes so that land use planning is consistent with NRM objectives throughout the Region. Local governments also have important management responsibilities and decision making roles that can support NRM in the Rangelands.

In addition, local government can be an important partner in implementing NRM actions with community groups, industry organisations and the Rangelands NRM Co-ordinating Group. Local government authorities may:

- provide a range of supporting structures for NRM projects and staff;
- be a central communicating body on aspects of NRM to their communities;
- link existing and future funding opportunities for community works and services to local NRM priorities;
- build on responsibilities and interest in fire management, weed and pest management, tourism promotion, and managing impacts on community NRM assets; and
- link NRM opportunities to their responsibilities as a major coastal land manager in the State.

Community, Industry and Non-government Organisations

In many ways community, industry and non-government organisations are the most important delivery agents of NRM in the Region. They include Traditional Owners, the pastoral, mining, tourism and fishing industries, the academic and scientific community, conservation groups, and other groups and individuals with an interest in a sustainable future for the Rangelands.

These groups have a good understanding of local issues, and of the community's capacity and available resources for implementation. As such the Rangelands NRM Co-ordinating Group is committed to supporting these organisations to implement on-ground NRM action through strategic investment.

These organisations also have the capacity to coordinate community action at the local level and undertake monitoring programs to ensure actions are meeting agreed targets. Industry organisations also have an important role to play in developing best practice systems and in promoting change.

4.3 Prioritisation

Prioritisation is effectively the culmination of community engagement. It is the synthesis of information obtained through community engagement processes about assets and threats, and seeks specific

community, industry and government input on what is therefore important and in turn a possibility for investment.

The NRM prioritisation process in the Rangelands was divided into two phases:

- **Phase I** saw fourteen "key NRM issues" (Table) (Appendix IX, Attachment One) ranked, which in turn provided the foundation for prioritising MATs. Phase I has been coordinated by each of the sub-regional groups, where they ranked the key issues against a number of social, economic and environmental factors. To do this they gave consideration to impact over time, extent, severity and likelihood of the impact occurring.
- **Phase II** involved further, detailed assessment of MATs, with consideration given to a number of additional issues such as cost and time of implementation, capacity of people to undertake actions, technical and logistical feasibility, and contributions to improving resource condition. This work was undertaken by the Rangelands NRM Co-ordinating Group.

A detailed outline of the prioritisation process is provided at Appendix IX.

The Co-ordinating Group acknowledges that there have been some limitations associated with way in which prioritisation has taken place in the Region and is commited to reviewing this during the next two years. Whilst the process itself is not fundamentally problematic, time constraints in developing the Strategy have meant that some of the elements driving prioritisation require review; namely the NRM issues and the MATs. However, whilst these need to be reviewed they do provide a useful starting point for further work in prioritising NRM actions in the Region, which is consistent with the adaptive management approach on which the regional delivery process is based.

Phase I – Ranking Issues

Implementation of Phase I was coordinated by the sub-regional NRM groups, as they had responsibility for designing and overseeing community engagement processes in each of the sub-regions, and have broad representation of community interests. Therefore the Rangelands NRM Co-ordinating Group considered them to be in the best position to advise it on what people in each of the Kimberley, Pilbara, Gascoyne-Murchison and Goldfields-Nullarbor thought about NRM.

The fourteen key NRM issues that were ranked in each sub-region are an aggregation of issues generated through the range of engagement processes with community, industry and government organisations to identify natural resource assets and the major threats to them. The Rangelands NRM Co-ordinating Group used the knowledge it gained from these engagement processes to determine "what" broad issues needed to be addressed throughout the Region, and then in linking the key issues to MATs "how" these issues might be addressed. In this way the prioritisation process provided a mechanism to bring together the information generated during consultation with community, industry and government organisations in a meaningful way.

Phase I required the completion of three tasks:

1. scoring and ranking the list of key NRM issues in each sub-region and then combining the scores to provide a ranked, whole-of-Rangelands list of issues. A weighting was applied to the scores to generally reflect the 10 areas of activity of the extension of NHT, and as such the intent of the Strategy. The weighting was environmental – 50, economic – 25 and social – 25;
2. grouping the ranked issues into three tiers. Groupings were determined on the basis of distinct differences between the scores where the highest ranking issues became group one, middle ranking issues became group two and the lower ranked issues became group three; and
3. determining which MATs addressed which issues and in turn allocating them a one, two or three depending on which tier the MAT's related issue occurred in.

Outcomes of Phase I

As previously mentioned after the ranked whole-of-Rangelands list of issues was finalised, the Rangelands NRM Co-ordinating Group determined the issue that each MAT primarily addressed. This provided an indicative (but not definitive) level of priority of each MAT. The ranked issues are provided below in Table 17:

Table 17: Ranked Key NRM Issues for the Rangelands

KEY NRM ISSUE	Mean Weighted Whole-of-Rangelands Score	Tier
Declining Native Vegetation Integrity	40.7	1
Defficient Planning for NRM	40.3	1
Low Community Capacity for NRM	39.0	1
Decreasing Primary Productivity	37.2	1
Declining Soil Condition	36.2	1
Altered Water Regimes	34.4	2
Declining Water Quality Supply	33.4	2
Declining Terrestrial Native Species and Communities Integrity	33.0	2
Poor Maintenance of Cultural and Heritage Values	32.9	2
Declining Inland Aquatic Water Quality	32.3	2
Declining Aquatic Native Species and Communities Integrity	28.6	3
Declining Marine Native Species and Communities Integrity	24.5	3
Declining Air Quality	22.9	3
Declining Marine Water Quality	21.1	3

Phase II – Prioritising MATs and Actions

Whilst Phase I of the prioritisation process provided an indicative level of priority of MATs, Phase II was focused on providing a more definitive priority for each MAT and its associated actions. In Phase II each MAT was subjected to strategic questioning about issues such as its feasibility, the capacity of people to implement it, its cost effectiveness and contribution to improving resource condition. This detailed questioning allowed the Rangelands NRM Co-ordinating Group to determine whether or not a MAT is:

- **Priority "A"** – Considered time critical and an important first step in achieving RCTs and/ or building critical capacity for NRM.

- **Priority "B"** –

    a. An important part of a program and/ or in achieving RCTs, and can be undertaken immediately.

    b. A MAT with "B" meets the criteria of Priority "A" but is considered to have low feasibility, but emerging new technologies or management practices are highly likely to increase feasibility in the near future.

- **Priority "C"** – Considered important but less of a priority for implementation in the immediate to short term. Priority "C" MATs are also likely to be dependant on the achievement of Priority "A" and "B" MATs first.

Phase II was undertaken by staff of Rangelands NRM Co-ordinating Group with expertise in a number of NRM areas and members of the Rangelands NRM Technical Working Group.

Understanding Priority

Following completion of the prioritisation process, the Rangelands NRM Co-ordinating Group has been able to determine the MATs that address the most important issues and then of these, which ones are technically feasible, cost effective, address the root cause of problems and make direct contributions to improving resource condition. This combined priority is indicated in the RCT and MAT tables as, by way of example, 1A, where:

- 1 indicates that a MAT addresses a highly ranked issue; and
- A indicates that it is considered time critical and an important first step in achieving RCT(s) and/ or building critical capacity for NRM.

Consequently a MAT with 1A assigned to it may be considered to be a high priority for investment.

This is not to suggest however that all, and only MATs (and associated actions) assigned 1A are automatically priorities for investment. As with the regional planning process, the Rangelands NRM Co-ordinating Group is required to address the full range of NRM matters in its Investment Plan. It is not obliged to invest all of its resources in only 1A MATs at the expense of other MATs, which address the suite of issues throughout the Rangelands. What it will do is look closely at the highest priority MATs across the range of NRM matters and consider these for investment. This deeper level of analysis and scrutiny of MATs and associated priorities is the subject of investment planning.

4.4 Investment for Implementation of NRM in the Rangelands

A Summary of Previous Investment in NRM in the Rangelands

In the first phase of NHT, stakeholder involvement in NRM in the Region was primarily via small and medium sized projects addressing local issues that were not generally within the context of a broad overarching plan or strategy. A notable exception to this was the Gascoyne-Murchison through the GMS, which resulted in an average annual investment of around $5 million for that sub-region. However, other than the GMS, NHT funding of projects averaged around $1.0 million per year (varied between $0.9 and $1.3 million per year) and was spread throughout the remainder of the Region.

Project assessment was carried out by a Regional Assessment Panel (RAP) and a State Assessment Panel (SAP), which considered issues of technical merit and potential improvements to natural resources as a result of implementing the project. NHT investment was invariably matched by State, industry and community investment at a ratio of between $1.90 and $2.50 for each NHT dollar invested. A separate process was also run for coastal projects through Coasts and Clean Seas and Coastwest programs.

Existing Investment

Following accreditation of the Rangelands NRM Strategy, investment will take place through its associated Investment Plan, which will see funding allocated to actions that contribute to priority targets in the Strategy.

However, while the Strategy has been under development, a number of priority projects have been funded by NHT and the NAP to maintain momentum in key NRM areas and address emerging priorities from Strategy development. In broad terms the areas of current NRM investment in the Rangelands are:

Impact of Fire on Landscapes, Land Management and Ecological Values

- Kimberley Fire Management Project - social and cultural attitudes towards fire and the land management, and habitat impacts of fire in the Kimberley (as much as 30 percent of the Kimberley is impacted by fire each year).
- Building fire management capacity in the Kimberley (NLP supported project).
- The above project is complemented by the Northern Australia Fire Project operating throughout the Kimberley, Northern Territory and North Queensland NRM Regions (Cross-Regional project).

Impact of a Range of Land Uses (primarily pastoral activity) on Landscape, Ecological and Hydrological Processes

- Raising the awareness of pastoral lease stakeholders (in the Southern Rangelands) in approaches to improve the ecological, hydrological and production management of pastoral lease areas.

Sustainable Grazing

- Completion of the upper Murchison River fencing and grazing management initiative (physical and management improvement of a greater than 200 kilometre section of river area).
- Catchment (pastoral lease parts) and river restoration work in the Roderick River (major tributary of Murchison River) and Lyndon River catchments.
- Upper Gascoyne River Rehabiliation Project.
- Total grazing management initiative in Goldfields-Nullarbor.
- Sustainable and Profitable Pastoral Management in Western Australia's Southern Rangelands.
- Building Partnerships to Improve Rangeland Management and Pastoral Profitability in Semi-Arid Australia (cross-Regional project).

Baseline Marine and Near Coastal Environments Information

- Derivation of marine water quality objectives for heavy marine traffic areas of the Pilbara's North-West Shelf.
- Determining baseline sediment quality for the Pilbara's North-West Shelf area.
- Coastal and marine management, including Indigenous understanding and management input to the North-West Kimberley coastal area (Saltwater Country Project).

Baseline Biological Information

- Broadening (in scope and coverage) of the state initiated Pilbara BioRegion biological survey.
- Targeted biological investigation of under-surveyed areas in Rangelands.

Management of Water Areas for Ecological Values

- Establishing priorities for wetland conservation and management in the Kimberley.

Restoration/ Rehabilitation of Water Areas for Ecological and Sustainable Use Values

- Implementation of the Lower Gascoyne River Action Plan – features improvements to / rehabilitation of degraded areas in the river and riparian zone.
- Extension of river rehabilitation work at lower and mid-Gascoyne River sites.
- Improved environmental management in the Ord River Region – includes key aspects of water use efficiency and water quality from the Ord irrigation area as well as Local Government planning, social and cultural aspects of Indigenous engagement in NRM and land management in the upper Ord catchment.

World Heritage Areas (Management Support)

- Project management, education/ interpretative and committees (community consultation and scientific advisory) support for the Shark Bay World Heritage Property (three discrete projects).

Weeds and Feral Animals

- Developing Capacity to Manage Noogoora Burr Infestations in the West Kimberley.
- Developing Pastoralists Capacity to Manage and Control Parkinsonia in the De Grey LCDC.
- Development of Strategies to Manage Vertebrate Pests in the Goldfields-Nullarbor.
- Mapping and Control of Sattelite Populations of Mesquite and Parkinsonia in the Gascoyne and Murchison Catchments.

Ord River [NAP] Region - Kimberley

- Improved Water Management in the Stage One ORIA.
- Other projects to target sustainable land management, water use and water and land quality aspects of the operation and potential expansion of the ORIA are under consideration.

Indigenous Engagement and Capacity Development

- Part of the New Facilitators project.
- Part of coastal and marine management, including Indigenous understanding and management input to the North West Kimberley coastal area (Saltwater Country Project).

Rangelands NRM Investment Plan

Following accreditation of the Strategy and Investment Plan approval, Australian and State Government investment in NRM in the Rangelands will be guided by the RCTs and MATs in the Rangelands NRM Strategy. The Rangelands NRM Investment Plan outlines major Programs and Activities for investment, through which investors can purchase outcomes in terms of contributions to targets and ultimately improvements to resource condition. These outcomes will be delivered through actions implemented by the partners referred to at the beginning of this Section.

Ultimately investment will target actions that provide the greatest benefits in a number of areas. Consequently the Investment Plan includes an analysis of trade-offs that must be made, emphasising the balance that needs to be struck between social, economic and environmental outcomes. The Co-ordinating Group acknowledges that over time this will require on-going consultation with key Regional stakeholders, who ultimately have to “live with” the trade-offs that are agreed to.

Whilst the targets in the Strategy guide investment through the extension of NHT and the NAP, these are only two potential sources of funding for NRM investment in the Rangelands, and there are a number of alternative funding sources and partners. In addition, government investment in the Region will be matched by at least equivalent community and industry partner resources of time, funds and technical expertise.

The relationship and commitments between partners will be formalised through partnership agreements with the Rangelands NRM Co-ordinating Group.

Rangelands NRM Programs

The State’s *Regional Investment Plans Guidelines and Processes*, developed by the State NRM Office indicate a program approach to regional NRM delivery, and the Rangelands NRM Investment Plan proposes three Programs under which investments will be delivered. The Programs are largely driven from the structure of the Strategy being:

1. **Sustainable Land Management;**
2. **Sustainable Management of Water; and**
3. **Sustainable Management of Coasts and Marine Waters.**

The Investment Plan includes a detailed description of each Program and the Activities that will deliver against them throughout the Region.

NHT and NAP Allocations to Programs

The Australian and State Governments wish to invest in NRM at a strategic level and expect that Investment Plans generally identify relatively large scale investments at the Program level. This includes identification of outcomes against targets, outputs and key activities. The Investment Plan does not specify individual project investments, and this is a matter that the Rangelands NRM Co-ordinating Group will determine once the Investment Plan is approved.

To determine the broad allocation of NHT and NAP funds at the Program level, the Investment Plan relies on the priority MATs identified in the Strategy. More specifically the allocations to Programs are based on the proportions of priority "1" MATs that relate to each Program. Details of the Programs, Activities and allocations can be found in the Investment Plan.

Investment Principles

The policy context for the Investment Plan is provided by the Bilateral Agreements for the extension of NHT and the NAP, particularly the overarching objectives and ten areas of activity of the extension of NHT. In addition to these there are other principles outlined in the *Regional Investment Plans Guidelines and Processes*, developed by the State NRM Office.

The overarching principle in determining investment priority is "return on investment" in terms of NRM outcomes. Additional principles adopted by the Rangelands NRM Co-ordinating Group are that:

- The value of the assets in environmental, economic or social terms; the nature, magnitude and trend of the threat to the assets; and the capacity for the threats to be managed, will be relevant in making investment choices in terms of which targets to invest against, and in which areas.
- Investments made under the NAP and NHT should encourage fundamental management changes rather than just a focus on repair and/ or rehabilitation projects.
- Investments made under the NAP and NHT should provide leverage to effect major change. As such, investment decisions will be influenced by both the scale of the outcomes likely to arise from the investment, and by the rate of change in the underlying resource condition anticipated from the investment.
- Government funds will flow to investment packages where third party contributions can improve the NRM outcomes.

Consideration of these principles will inform the Rangelands NRM Co-ordinating Group's assessment of the trade-offs that need to be made when allocating resources in a consistent, rigorous and transparent manner. Specifically the Group will need to be able to determine the relative merits of a particular action against others, and allocate resources accordingly. To facilitate this it has developed criteria for assessing "project quality", which are detailed in the Investment Plan.

The Rangelands NRM Co-ordinating Group also recognises that the principles guiding public investment in NRM in the State's other NRM Regions, outlined in the Salinity Investment Framework (SIF), are also generally applicable to the Rangelands. They are:

- The top priority public investments are those which generate the greatest public benefits per dollar of public investment.
- Direct assistance to landholders to undertake action should be strategic and should not exceed the public benefits that result.
- Where priority is high and net public benefits are sufficient, government should be prepared to take strong action to ensure protection of the asset.
- Where public priority is low but there are extensive private assets at risk, public investment should be aimed at industry development.
- Inevitably, a targeted investment Strategy in management will result in an unequal distribution of investment across the State.
- Government must fulfil its statutory obligations for land, natural resources and functions (such as research) when it sets its priorities for investment in action.
- The processes required for priority-setting will involve ongoing learning and need constant feedback.
- Setting priorities must proceed even when there is only limited or imperfect information on prevailing environmental, social and economic circumstances.

4.5 Monitoring and Evaluation Framework

Consistent with the adaptive management principles on which the regional NRM planning and delivery process is based, it is essential that a robust framework for monitoring and evaluation is established to support the Rangelands NRM Strategy. Such a framework is essential for reporting on the contributions that investments are making to improve the resource condition of priority assets in the Region.

Monitoring and evaluation are also important for improving accountability and transparency, and will provide the Rangelands NRM Co-ordinating Group and its partners with information to improve decision making about NRM investment in the future. Essentially, it completes a feedback loop (Figure) to decision makers and investors on “bang for buck”.

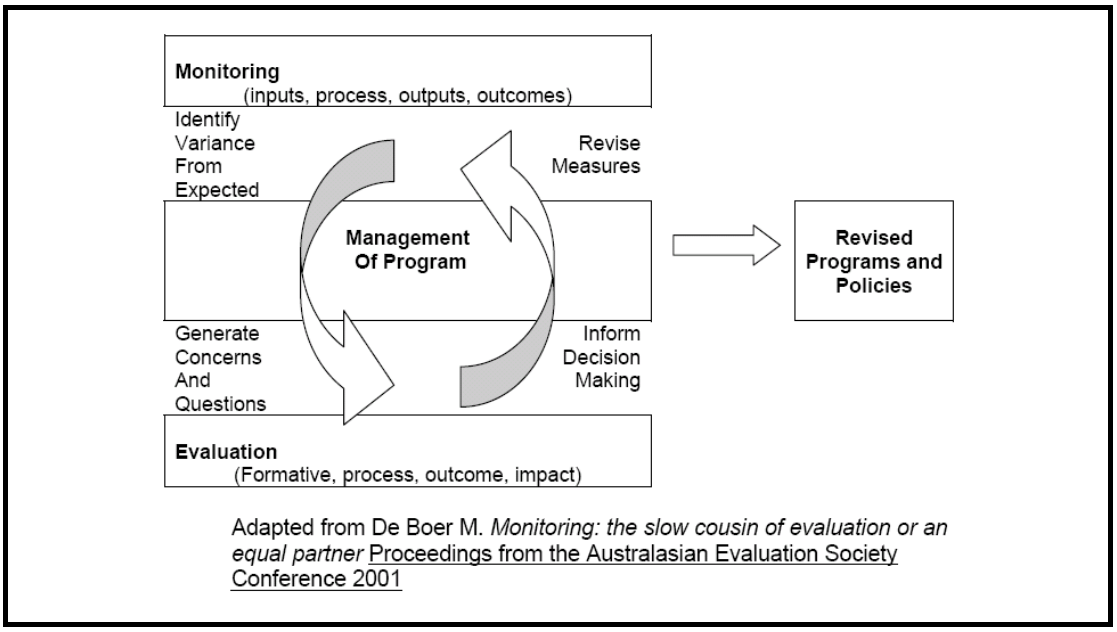


Figure 17: Monitoring and Evaluation Feedback Loop

To guide development of a monitoring and evaluation framework, the Australian, and State and Territory Governments have established the *National NRM Monitoring and Evaluation Framework*, which is aimed at assessing the:

- health of the nation's land, water, vegetation and biological resources; and
- performance of programs, strategies and policies that provide national approaches to the conservation, sustainable use and management of these resources.

The Framework requires the development of processes that are useable, cost-effective, accurate, comprehensive and transparent, and will result in monitoring and reporting on Regional, State and national outcomes. To this end the Rangelands NRM Co-ordinating Group is committed to establishing a framework for monitoring and evaluation that meets the requirements of the National Framework. In particular it will ensure that the framework monitors contributions to the Strategy's RCTs and that these in turn address the 10 "Matters for Targets" outlined in the Framework and in the *National Framework for NRM Targets and Standards*. The Strategy currently defines Regional RCTs that address the Matters for Targets and the Co-ordinating Group will continue to refine these over time. The Matters for Targets are:

- Land salinity;
- Soil condition;
- Native vegetation communities' integrity;
- Inland aquatic ecosystems integrity (rivers and other wetlands);
- Estuarine, coastal and marine habitats integrity;
- Nutrients in aquatic environments;
- Turbidity/ suspended particulate matter in aquatic environments;
- Surface water salinity in freshwater aquatic environments;
- Significant native species and ecological communities; and
- Ecologically significant invasive species.

The framework will specify the need to develop indicators for reporting on progress toward MATs.

Establishing a framework will require input from State Government agencies, which very often have statutory responsibility for monitoring and reporting on resource condition, and which consequently have established long term monitoring programs. The Rangelands NRM Co-ordinating Group will seek strong partnerships with State Government agencies with responsibilities for reporting on natural resource condition. The Co-ordinating Group will also work with the State to develop protocols for data management, collection and delivery, in conjunction with other regional NRM groups.

In working with State agencies, the Co-ordinating Group will ensure that its framework for monitoring and evaluation is consistent with the *Monitoring and Evaluation Implementation Plan for the NAP and NHT in Western Australia*.

REFERENCES

Abbot, I., 1997, Extinctions in Western Australia, *Landscope* vol. 12, no. 3, pp. 49-53

Aboriginal and Torres Strait Islanders Commission, retrieved from http://www.atsic.gov.au/programs/Economic/CDEP/CDEP_Organisations/cdeps.asp?rc=6550

Access Economics, 2003, *The economic contribution of tourism to the state of Western Australia: A tourism satellite account-based analysis*, Western Australian Tourism Commission, pg 45

Allen, A. D. and Geological Survey of Western Australia, 1996, *Hydrogeology of the northeastern goldfields, Western Australia*, Geological survey of Western Australia, Perth

Anon, 1993, *Report of the Pastoral Wool Industry Task Force to Hon Monty House MLA, Minister for Primary Industry Western Australia*, Government of Western Australia, Perth

Anon, 1999, *Threat Abatement Plan for Predation by Feral Cats*, National Feral Animals Control Program, Biodiversity Group, Environment Australia, Canberra

Anon, 1999, *Threat Abatement Plan for Predation by the European Red Fox*, Biodiversity Group, Environment Australia

Anon, 2001, *National Objectives and Targets for Biodiversity Conservation 2001-2005*, Environment Australia, Canberra

Anon, 2001, *National Framework for the Management and Monitoring of Australia's Native Vegetation*, Natural Resource Management Ministerial Council, Canberra

Anon, 2003, *Preliminary Agency Statement of Natural Resource Management Priorities in Western Australia*, Department of Agriculture, Department of Conservation and Land Management, Department of Environment, and Department of Fisheries

Australian Bureau of Statistics, 2004. *Measures of Australia's Progress*, Retrieved: February 10, 2005, from http://www.abs.gov.au/ausstats/abs@.nsf/94713ad445ff1425ca25682000192af2/62c0ccada5421f81ca256e7d0000264b!OpenDocument

Australian Bureau of Statistics, 2004*, National Regional Profile*, cat. No. 1379.0.55.001, ABS, Canberra

Ball, J., 2001, *Inland Waters Theme Report: Water quality and sources of pollution (continued) Eutrophication and algal blooms.* Retrieved: February 9, 2005, from http://www.deh.gov.au/soe/2001/inland/water02-2a.html

Bayly, I. A. E. 1999, Review of how Indigenous people managed for water in desert Regions of Australia, *Journal of the Royal Society of Western Australia*, 82:17-25

Beard, J.S., 1990, *Plant Life of Western Australia*, Kangaroo Press, New South Wales

Beard, J. S., Chapman, A. R., and Gioia, P., 2000, Species Richness and Endemism in the Western Australian Flora*. Journal of Biogeography* vol. 27 pp. 1257-1268

Berry, P.F. and Wells, F.E., 2000, Survey of the marine fauna of the Montebello Islands, Western Australia and Christmas Islands, Indian Ocean, *Records of the Western Australian Museum*, Supplement 59: 1-27

Brockman, J., 1987, 'He Rode Alone', being the Adventures of Pioneer Julius Brockman from his Diaries. Artlook Books, Perth, Australia

Burnside D.G., Holm A., Payne A.L. and Wilson G., 1995, *Reading the Rangeland: a Guide to the Arid Shrublands of Western Australia*. Department of Agriculture Western Australia, Perth

Burt J., Morrissey, J, and Holm, A 1989, Revised *Carnarvon – agricultural and pastoral activities.* Department of Agriculture, Government of Western Australia, Perth

Chance, K., 2004, *New funding for cane toads,* media release, Government of Western Australia, Perth, 11 December

Clark, B., 1992, Yamatji: *Aboriginal Memories of the Gascoyne*, Hesperian Press, Perth

Commander, D.P., 1990, Outline of the Hydrogeology of the Eucla Basin, in: *Proceedings of the International Conference on Groundwater in Large Sedimentary Basins*, Perth 1990, Australian Water Resources Council, Conference Series No. 20, pp 70-78

Commander, D.P., 1993 *Groundwater in the goldfields in Kalgoorlie as a Regional Industrial Centre*, in: Proceedings of the National Conference of the Australasian Institute of Mining and Metallurgy and the Institution of Engineers, Kalgoorlie, October 1993, p. 11-13

Cooperative Research Centre for the Sustainable Development of Tropical Savannas, 2001, *Savanna Burning*, Tropical Savanna CRC, Darwin.

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Niell, R.V., Paruelo, J., Raskin, R.G., Sutton, P., and van den Belt, M, 1997, The value of the world's ecosystem services and natural capital, *Nature* (387):253-260

Dampier Salt, 2000, *Social and Environmental Review*, Clarity Communications, Perth, Western Australia

Department of Agriculture, 2002, *Rangelands Strategy Supporting Material Appendix 1*, A Department of Agriculture internal policy document, Government of Western Australia, Perth

Department of Agriculture, 2003, edited by Dalton, W and Bright, F, *Information on Pastoral Businesses in the Rangelands of Western Australia*, Government of Western Australia, Perth

Departments of Agriculture, Conservation and Land Management, Environment and Fisheries 2003, *Preliminary Agency Statement of Natural Resource Management Priorities in Western Australia*, Government of Western Australia, Perth

Department of Agriculture and Department of Environment, 2000, *Ord Land and Water Management Plan 2000*, Government of Western Australia, Perth

Department of Conservation and Land Management, A. L. Chapman, *et al*, 1994, *Goldfields Region : Regional management plan 1994-2004*, Department of Conservation and Land Management for the National Parks and Nature Conservation Authority and the Lands and Forest Commission, Government of Western Australia, Perth

Department of Conservation and Land Management, 1999, *Environmental Weed Strategy for Western Australia*, Dept of Conservation and Land Management, Department of Agriculture, CSIRO, Kings Park and Botanic Garden, Perth

Department of Conservation and Land Management 2000, *Shark Bay Terrestrial Reserves Management Plan 2000 – 2009.* Government of Western Australia, Perth

Department of Conservation and Land Management, and MPRA, 2000, *Regional Perspective(s): The Dampier Archipelago and Montebello/ Barrow Islands*, Government of Western Australia, Perth

Department of Conservation and Land Management 2001, *Conserving Threatened Ecological Communities*, Retrieved: January 19, 2005, from http://www.naturebase.net/plants_animals/watscu/pdf/tec/tecbrochure_sb.pdf

Department of Conservation and Land Management (Marine Conservation Branch) 2002, *A Strategic Framework for marine research and monitoring in the Shark Bay World Heritage Property*, Government of Western Australia, Perth

Department of Conservation and Land Management, 2003, *Discussion Paper on Management Plan for Burrup Peninsula Conservation Reserve*, Government of Western Australia, Perth

Department of Conservation and Land Management 2004, *Performance Assessment Report 2003/ 2004 Shark Bay Marine Reserves,* Government of Western Australia, Perth

Department of Conservation and Land Management 2004, *Saving our Threatened Wildlife: WA's Threatened Ecological Communities.* Retrieved: January 19, 2005, from http://www.naturebase.net/plants_animals/watscu/tec.html

Department of Conservation and Land Management, 2004, *Towards a Biodiversity Conservation Strategy for Western Australia*, Government of Western Australia, Perth

Department of Conservation and Land Management n.d. *Western Australian Flora Statistics.* Retrieved: February 15, 2005, from http://florabase.calm.wa.gov.au/statistics/

Department of Environment 2002, *Statewide Waterways Needs Assessment*, Government of Western Australia, Perth

Department of Environment 2002, *Western Australia Water Assessment*, Government of Western Australia, Perth

Department of Environment and Heritage (Interim Marine and Coastal Regionalisation for Australia Technical Group) 1998, *Interim Marine and Coastal Regionalisation for Australia: an ecosystem-based classification for marine and coastal environments* Version 3.3, Commonwealth of Australia, Canberra

Department of Environment and Heritage, 2001, *A Directory of Important Wetlands*, Commonwealth of Australia, Canberra

Department of Environment and Heritage, 2001, *Landscape Health in Australia: A rapid assessment of the relative condition of Australia's bioRegions and sub-regions*, National Land and Water Resources Audit, Canberra

Department of Environment and Heritage 2004, *National Biodiversity Hotspots.* Retrieved: February 10, 2005, from http://www.deh.gov.au/biodiversity/hotspots/index.html

Department of Environment and Heritage 2004, *National Biodiversity Hotspots.* Retrieved: 21 June, 2005, from http://www.deh.gov.au/Indigenous/fact-sheets/ipa.html

Department of Fisheries, n.d. *Introduced Fish Species in Western Australia.* Retrieved: February 9, 2005, from http://www.fish.wa.gov.au/hab/broc/inland/fsfw03.html

Department of Fisheries 2002, *Fisheries Environmental Management Plan for the Gascoyne Region*. Government of Western Australia, Perth

Department of Fisheries, 2003, *State of the Fisheries Report 2002/ 2003*, Government of Western Australia, Perth

Department of Fisheries, 2004, Fisheries Management Paper No. 81: A Quality Future for Recreational Fishing in the Pilbara/ Kimberley, Government of Western Australia, Perth

Department of Fisheries, 2004, www.fish.wa.gov.au/hab/, Accessed 7/12/2004

Department of Fisheries, 2004a, *Future Management Arrangements for Western Australia's Temperate Shark Fisheries.* Fisheries Management Paper No. 180, Government of Western Australia, Perth

Department of Fisheries, 2004b, A Quality Future for Recreational Fishing in the South Coast – A Five Year Strategy for Managing the Recreational Component of the Catch, Fisheries Management Paper No. 182, Government of Western Australia, Perth

Eyre Bird Observatory, 1992, *Eyre Bird Observatory Warden's Report no. 6: 1988-1992.* Eyre Bird Observatory, Western Australia

Department of Indigenous Affairs (Kimberley Region), 2004, Retrieved: September 2004 from http://www.dia.wa.gov.au/DIA/Regions/Kimberley.

Department of Industry and Resources, 2004, *Prospect*, Department of Industry and Resources Western Australian Government Dec 2004 – February 2005, Perth

Department of Industry and Resources, 2004, *Western Australian Mineral and Petroleum Statistics Digest 2003–04*: Department of Industry and Resources, 57p.

Department of Local Government and Regional Development and Goldfields-Esperance Development Commission, 2001, *Goldfields-Esperance economic perspective : an update on the economy of Western Australia's Goldfields Region*, Kalgoorlie, Western Australia

Department of Local Government and Regional Development, 2003, *Indicators of Regional Development in Western Australia*, Government of Western Australia, Perth

Department of Natural Resources, 2003, *Mesquite: Control and management options for mesquite (Prosopis spp.) in Australia*, Department of Natural Resources, Queensland

Department of Transport and the Pilbara Development Commission, 1997, *Pilbara Regional Transport Strategy*, Government of Western Australia, Perth

Durack, M., 1997, *Kings in Grass Castles*, Bantam Books, Sydney

Environmental Protection Authority, 2001, Guidance Statement for protection of tropical arid zone mangroves along the Pilbara coastline, *Guidance Statement No. 1*, Government of Western Australia, Perth

Environmental Protection Authority, 2001, Guidance Statement for protection of tropical arid zone mangroves along Pilbara coastline, *Final Guidance No.* 1, Government of Western Australia, Perth

Environmental Protection Authority, 2003, Guidance for the Assessment of Environmental Factors (in accordance with the *Environmental Protection Act 1986*), *Consideration of Subterranean Fauna in Groundwater and Caves during Environmental Impact Assessment in Western Australia No. 54*, Government of Western Australia, Perth

Environmental Protection Authority, 2004, *Environmental Protection and Ecological Sustainability of the Rangelands in Western Australia*, Position Statement Number Five, Government of Western Australia, Perth

Field C., 2004, *Shire of Dundas Coastal Management Plan*, Shire of Dundas, Norseman, Western Australia

Findlay, M. 1983, *Carnarvon: Reflections of a Country Town*. Shire of Carnarvon, Western Australia

Fisher, A., Hunt, L., James, C., Landsberg, J., Phelps, D., Smyth, A., Watson, I. 2004. Review of total grazing pressure management issues and priorities for biodiversity conservation in Rangelands: A resource to aid NRM planning, Desert Knowledge CRC Project Report No. 3 (August 2004); Desert Knowledge CRC and Tropical Savannas Management CRC, Alice Springs

Fuller, B., 1970, *The Nullarbor Story*, Adelaide, Rigby

Ferguson, K. M. and Ruddock, I., 2001, Mineral occurrences and exploration potential of the east Pilbara: *Western Australia Geological Survey, Report 81*, 114 p.

Fyfe, W.V., 1940, Report of the Royal Commission appointed to inquire into and report upon the financial and economic position of the pastoral industry in the leasehold areas in Western Australia. Government Printer, Perth, Australia

Gascoyne Development Commission 2003, Gascoyne Economic Perspective – An Update on the Economy of Western Australia's Gascoyne Region, Government of Western Australia, Perth

Geological Survey of Western Australia, 2001, *Western Australia atlas of mineral deposits and petroleum fields 2001*: Western Australia Geological Survey, 34 p.

Gifford, P., 2002, *Black and white and in between: Arthur Dimer and the Nullarbor*, Carlisle, Western Australia, Hesperian Press

Goldfields-Esperance Regional Development Advisory Committee and Western Australian Department of Regional Development and the North West, 1986, *Goldfields-Esperance Regional profile*, Kalgoorlie, Western Australia

Greiner, R., Stokes, C., Cowell, S., Tapsall, S., Kinloch, J., Kininmonth, S., Murray, A., 2001, *A socio-economic profile of the natural resource-based industries in the (east) Kimberley,* CSIRO Sustainable Ecosystems: Townsville

Gueho, R., 2003, *Icons of the Kimberley – An A to Z for Guides and Travellers*, Northern Habitat, Broome

Hacker, R. B., 1982, *The problems and prospects of the Kimberley pastoral industry*, (Edited by R.B. Hacker), Technical Report No. 6, Division of Resource Management, Department of Agriculture, Government of Western Ausralia, Perth

Halse, S., 2002, *Tiny creatures help guide Pilbara development*, media release, Department of Conservation and Land Management, 20 June

Harvey N., and Caton B., 2003, *Coastal Management in Australia,* Oxford University Press, Victoria, Australia. ISBN: 0195537947. 342pp

Hassan, L. Y., 2000, Mineral occurrences and exploration potential of the east Kimberley: *Western Australia Geological Survey Report 74*, 83 p.

Hassan, L. Y., 2004, Mineral occurrences and exploration potential of the west Kimberley: *Western Australia Geological Survey Report 74*, 88 p.

Higgins Wood & Associates, 1995 *Pilbara/ Gascoyne Islands Ecotourism Management Strategy:* Volume II – Technical and Detail Papers, Pilbara Development Commission, Government of Western Australia, Perth

Holm, A., M. Friedel, *et al*, 2002, *Rangeways: community based planning for ecologically sustainable land use in the Western Australian Goldfields*, Department of Agriculture, Government of Western Australia: 74, Perth

House, M.G., 1991, *Select Committee into Land Conservation, Final Report*, Western Australia Legislative Assembly, Perth

House, M.G., Graham, L., McNee, W.J., Read, K.J. and Gallop, G.I., 1991, *Select Committee into Land Conservation, Discussion Paper No. 3, Pastoral Region of Western Australia*, Western Australia Legislative Assembly, Perth

Interim Marine and Coastal Regionalisation for Australia Technical Group, 1998, *Interim Marine and Coastal Regionalisation for Australia: an ecosystem-based classification for marine and coastal environments*, Version 3.3., Australian Government Department of Environment and Heritage, Canberra

Jennings, B.G., 1979, *The present and future pastoral industry of Western Australia*, Western Australian Government Printer, Perth

Johnson, S. L. and University of Western Australia, Department of Environmental Engineering, 2000, *Hydrogeology of the northern goldfields, Western Australia*

Johnson, S.L., Commander, D.P. and O'Boy, C.A., 1999, *Groundwater Resources of the Northern Goldfields, Western Australia,* Water and Rivers Commission, Hydrogeological Record Series, Report HG 2

Johnston, R.E, 1990, *Mangroves and mangrove birds of Western Australia*, Rec. Western Australian Museum, Supplement 32: 120pp.

Jones, D.S (Ed), 2004, *Marine Biodiversity of the Dampier Archipelago Western Australia 1998-2002*, Western Australian Museum, Western Australia, Perth

Kay, W. R., Smith, M. J., Pinder, A. M., McRae, J. M., and Halse, S. A. 1999, Patterns of distribution of macroinvertebrate families in rivers of north-western Australia*, Freshwater biology*. - Vol. 41

Kendrick, P., 2001, *Great Sandy Desert 2 (GSD2 – Mackay sub-region)*, in May, J. E., and McKenzie, N. L. (eds), *A Biodiversity Audit of Western Australia's 53 Biogeographical Sub-regions in 2002*, Government of Western Australia, Perth

Kewagama Research, 1997, Ord River Recreational Fishing Survey

Kimberley Language Resource Centre, Halls Creek, 1991

Kimberley Development Commission, 2003, *Kimberley Economic Perspective – An update on the economy of Western Australia's Kimberley Region,* KDC, Department of Local Government and Regional Development, Perth

Kimberley Development Commission, 2004 *Kimberley Population Distribution*, Retrieved: October 2004 from http://www.kdc.wa.gov.au/index

Laing, I.A.F. and Hauck, E.J., 1997, Water harvesting from granite outcrops in Western Australia, *Journal of the Royal Society of Western Australia*, 80:181-184

Lane, J. A. K. and McComb, A. J. 1988, Western Australian Wetlands, in *The Conservation of Wetlands*, A.J. McComb and P.S. Lake (eds), Surrey Beatty, NSW

Lefroy, R.F.B. and Nixon, M 1988, *Road to the Murchison: An illustrated story of the district and its people.* Vanguard Press, Perth, Western Australia

Len Z., 2003, *A guide to the Kimberley Coast Wilderness – north western Western Australia*, Wild Discovery - www.wilddiscovery.com.au

Lendich, Z., 2003, *Proposed Strategy for the Development of the Western Australian Aquaculture Industry*, Final Report to Minister for Agriculture, Forestry and Fisheries. Government of Western Australia, Perth

Looby, G., 1997, *Management Options for the Pilbara Demersal Line Fishing*, Fisheries Management Paper No. 111, Department of Fisheries, Government of Western Australia, Perth

Main, B., 1997, Granite outcrops: A collective ecosystem, *Journal of the Royal Society of Western Australia*, 80:113-122

Marine Parks and Reserves Authority, and Department of Conservation and Land Management, 2004, Ningaloo Marine Park Draft Management Plan and indicative management plans for the extension to the existing park and the proposed Muiron Islands Marine Management Area, Government of Western Australia, Perth

May, J.E. and N.L McKenzie (Eds), 2003, *A Biodiversity Audit of Western Australia's 53 Biogeographical Sub-regions in 2002*, Department of Conservation and Land Management, Government of Western Australia, Perth

McKenzie, N.L. J. E. May, and S. McKenna (Eds), 2003, *BioRegional Summary of the 2002 Biodiversity Audit for Western Australia*, Department of Conservation and Land Management, Government of Western Australia, Perth

McKenzie, NL and Robinson AC, eds., 1987, *A biological survey of the Nullarbor Region South and Western Australia in 1984*, Department of Conservation and Land Management, and Department of Environment and Planning

McKeon, G.M., Hall, W. Henry, B.H., Stone, G. and Watson, I.W. (Eds), 2004, *Pasture degradation and recovery in Australia's Rangelands. Learning from history.* Queensland Department of Natural Resources, Mines and Energy, Brisbane, Australia, 256 pp

Miller, C., 1996, Photographical History of Carnarvon and the Gascoyne Region, Shire of Carnarvon, Western Australia

Morgan D.L., Gill H.S., Maddern M.G. and Beatty S.J., 2004, Distribution and impacts of introduced fishes in Western Australia, New Zealand, *Journal of Marine and Freshwater Research*, Vol. 38: 511-523, The Royal Society of New Zealand

Morris, K., 1990, *Dampier Archipelago Nature Reserves: Management Plan 1990-2000*, Department of Conservation and Land Management, Government of Western Australia, Perth

Morris K., 1995. *Recovery Outline – Shark Bay Mouse*, In The Action Plan for Australian Rodents, Retrieved February 10 2005 from http://www.deh.gov.au/biodiversity/threatened/action/rodents/rodap3.html

Morton, S.R., Short J. and Barker, R.D., 2004, *Refugia for Biological Diversity in Arid and Semi-arid Australia*. *Biodiversity Series Paper 4.* Retrieved: February 4, 2005, from http://www.deh.gov.au/biodiversity/publications/series/paper4/bio1023.html

MPRSWG, 1994, *A Representative Marine Reserve System for Western Australia*, Report of the Marine Parks and Reserves Selection Working Group, Department of Conservation and Land Management, Government of Western Australia, Perth

National Land and Water Resources Audit, 2001, *Rangelands – Tracking Changes, Australian Collaborative Rangeland Information System*, Commonwealth of Australia, Canberra

Natural Resource Management Ministerial Council, 2003, *National Natural Resource Management Monitoring and Evaluation Framework*, Commonwealth of Australia, Canberra

Osbourne S., Bancroft, K., D'Adamo, N. and Monks L., 2000 *Regional Perspective: The Dampier Archipelago/ Cape Preston*, Department of Conservation and Land Management and the Marine Parks and Reserves Authority, Government of Western Australia, Perth

Osbourne S., Bancroft, K., D'Adamo, N. and Monks L., 2000, *Regional Perspective: Montebello/ Barrow Islands*. Department of Conservation and Land Management and the Marine Parks and Reserves Authority, Government of Western Australia, Perth

Payne, A.L. and Mitchell, A.A., 2002, *Pasture Condition Guides for the Pilbara*, Miscellaneous Publication 19/ 2002, Department of Agriculture, Government of Western Australia, Perth

Pedretti, M. and Paling, E. L, 2001, *Western Australian Mangrove Assessment Project*, Murdoch University, Perth

Pilbara Development Commission, 1995, *Pilbara Regional Profile*, Government of Western Australia, Perth

Pringle, H. J. and Department of Agriculture, 1994, *Pastoral resources and their management in the North-Eastern Goldfields, Western Australia: an interpretation of findings from the rangeland survey of the North-Eastern Goldfields* (Pringle, Van Vreeswyk and Gilligan 1994), Government of Western Australia, Perth

Pringle, H. and Tinley, K., 2003, Are we overlooking critical geomorphic determinants of landscape change in Australian Rangelands?, *Ecological Management and Restoration*, 4: 180-186.

Pringle, H. J., Watson, I. W. and Tinley, K. L., submitted to Landscape Ecology. *Rangeland improvement, or ongoing degradation – reconciling apparent contradictions from the arid Rangelands of Western Australia*, Unpublished

Rijavec, F., Harrison, N. and Ngurin Aboriginal Corporation, 1993, *Exile and the Kingdom* (video), Australian Film Commission/ ATSIC/ Western Australian Film Council/ NAC

Roberts, CR, McClean, CJ, Veron, JEN, Hawkins, JP, Allen, GR, McAllister, DE, Mittermeier, CG, Schueler, FW, Spalding, M, Wells, F, Vynne, C, and Werner, TB., 2002, Marine biodiversity hotspots and conservation priorities for tropical reefs, *Science* 295: 1280-1285.

Ruddock, I., 1999, Mineral occurrences and exploration potential of the west Pilbara: *Western Australia Geological Survey, Report 70*, 63 p.

Ruddock, I., 2003, Mineral occurrences and exploration potential of the North Kimberley: *Western Australia Geological Survey, Report 85*, 58 p.

SCMG, 2001, *Southern Shores: 2001 – 2021: A Strategy to Guide Coastal and Marine Planning and Management in the South Coast Region of Western Australia*, written by: B Green, for: The South Coast Management Group (SCMG), Western Australia, Albany

Semeniuk, V., 1997, *Selection of Mangrove Stands for Conservation in the Pilbara Region of Western Australia* – A Discussion, (Unpublished)

Sharp, B., n.d., *Long-term Landscape-scale Woody Vegetation Dynamics in an Australian Tropical Savanna.* Retrieved Feb. 3 2005 from http://savanna.ntu.edu.au/education/students/ben_sharp.html

Shire of Broome, 2004, *Shire of Broome 2004 Directory*, Shire of Broome, Western Australia

Shire of Halls Creek, 2004, *Halls Creek Shire Directory 2004/ 2005*, Shire of Halls Creek, Western Australia

Singor, M., 1999, Hooded plover report No. 2 1996-1999, *The search continues*. Supplement to Western Australia Bird Notes, No. 90, June 1999

South Coast Regional Initiative Planning Team, 2004, (draft), *Southern Prospects: 2004-2009 Draft for Public Comment*, Western Australia, Albany

State Wild Dog Management Advisory Committee, 2004, *Western Australian Wild Dog Management Strategy 2004*, Miscellaneous Publication 22/2004, Government of Western Australia, Perth

Sumner, N. R., Williamson, P. C. and Malseed, B. E., 2002, *A 12-month survey of recreational fishing in the Gascoyne bioRegion of Western Australia during 1998-99*, Fisheries Research Report No. 139, p54, Department of Fisheries, Government of Western Australia, Perth

Tapin, A. R., 2003, *Rainbowfish Habitats: The Kimberley*, Retrieved: February 2, 2005, from http://members.optusnet.com.au/chelmon/Kimberley.htm

Taylor, J.G., 1996, *Seasonal occurrence, distribution and movements of the whale shark*, (*Rhincodon typus*) at Ningaloo Reef Western Australia, Marine and Freshwater Research 47(4): 637-642

Taylor, J. 2003, *Aboriginal Population Profiles for Development Planning in the Northern East Kimberley*, Research Monograph No. 23, Centre for Aboriginal Economic Policy Research, Canberra

Thompson-Dans C., G.Kendrick and K Bancroft, 2003, *Researching the Recherché*, In Landscope, 18 (4): 10-17, Winter 2003

Thorburn D.C. and Morgan D.L., 2004, The northern river shark Glyphis sp. C (Caracharhinidae) discovered in Western Australia, *Zootaxa* Vol. 685 pp 1-8

Tinley, K.L., 1986, Ecological Regions of Western Australia: The Basis for Coordinated Planning and Management of Conservation and Development, *Towards a State Conservation Strategy: Invited Review Papers*, Department of Conservation and Environment, Bulletin 251, 286pp

Tongwway, D.J., 1994, *Rangeland Soil Condition Assessment Manual.* CSIRO Publishing, Melbourne, Victoria

Tongway, D.J. and Ludwig, J.A., 1994, Small-scale resource heterogeneity in semi-arid landscapes, *Pacific Conservation Biology*, 1, 201-208

Valli, J 1983, *Gascoyne Days*, St George Books, Perth

Water and Rivers Commission, 1997, *The State of the Northern Rivers*. Government of Western Australia, Perth

Water and Rivers Commission 2000, *Stream Ecology*, Water and Rivers Commission River Restoration Report No., RR7

Water and Rivers Commission, 2000, *Water notes: Protecting Riparian Vegetation*, Government of Western Australia, Perth

Water and Rivers Commission, 2002, Water Resources Allocation in the Goldfields and the Officer Basin Western Australia, discussion paper, in: *Goldfields Esperance Water Supply Background Papers, Draft Water Supply Strategy*, Government of Western Australia, Perth

Water and Rivers Commission, n.d., Retrieved February 4 2005, from http://www.wrc.wa.gov.au/under/statewqassess/Ord_home.htm

Watson, I.W., 2002, A selected chronology of historical, biological, social, economic and institutional factors that relate to land management, particularly degradation episodes in Western Australia – West Gascoyne and Upper Gascoyne. Appendix 1 in: Learning from history: can seasonal forecasting prevent land and pasture degradation of Australia's grazing lands? editors G.M. McKeon, and W.B. Hall, Technical Report for the Climate Variability in Agriculture Program (QNR14), May 2002

Watson, I. W., 2003, Preventing desertification and promoting rehabilitation in Western Australian semi-arid Rangelands at the individual property scale, *Global Perspective in Range Rehabilitation and Prevention of Desertification*, *The 2003 Obihiro Asia and the Pacific Seminar on Education for Rural Development*, (Editor-in-Chief, J. Takahashi), Obihiro University of Agriculture and Veterinary Medicine, Hokkaido, Japan, Aug 26 – September 2, 2003, pp 33-44

Watson, I.W., McKeon, G.M. and Wilcox, D.G., 2004, Modelling climate and management effects on shrub populations in the Gascoyne area of Western Australia and the North East District of South Australia. In: *Pasture degradation and recovery in Australia's Rangelands. Learning from history.* (Eds: G.M. McKeon, W. Hall, B.H. Henry, G. Stone and I.W. Watson), Queensland Department of Natural Resources, Mines and Energy, Brisbane, Australia, pp. 174-190

Watson, I. and Thomas, P., 2003, Monitoring shows improvement in Gascoyne – Murchison Rangelands. *Range Management Newsletter,* 03/1, 11-14

Watson, John, Hamilton-Smith, Elery, Gillieson, David and Keirnan, Kevin (Eds), 1997, *Guidelines for Cave and Karst Protection*, IUCN, Gland, Switzerland and Cambridge, UK 63pp

Wells, F.E., Walker, D.I. and Jones, D.S., 2003, *Proceedings of the eleventh international marine biological workshop: the marine flora and fauna of Dampier, Western Australia*, Western Australian Museum, Perth 587 pages

Western Australian Museum, 2000, *Biodiversity of the southern Carnarvon Basin.* A. H. Burbidge, M. S. Harvey and N. L. McKensie (eds), Western Australian Museum, Perth

Western Australian Museum, 2005. Retrieved February 7, 2005, from http://www.museum.wa.gov.au/faunabase/prod/index.htm

Western Australian Planning Commission, 2000, *Goldfields-Esperance Regional planning Strategy*, Government of Western Australia, Perth

Western Australian Planning Commission 2004, *Ningaloo Coast Regional Strategy – Carnarvon to Exmouth*, Government of Western Australia, Perth

Western Australian Planning Commission, 2004, *Coastal Planning Program – Status of Coastal Planning in Western Australia*, Government of Western Australia, Perth

Western Australian Tourism Commission 2002, Western Australian Tourism Commission, research review on domestic activity, Gascoyne, Government of Western Australia, Perth

Whisenant, S.G., 1999, *Repairing Wildlands: A Process-Oriented, Landscape-Scale Approach*, Cambridge Univeristy Press, London

Williams, O.B., Suijdendorp, H. and Wilcox, D.G., 1980, The Gascoyne Basin. In: Desertification. Associated case studies prepared for the United Nations Conference on Desertification (Nairobi 1977), editors M.R. Biswas and A.K. Biswas, Pergamon Press, Oxford, England. 3-106

Williams, P.J., Pen L.J. and Alford J.J., 1999, Wild Rivers of Western Australia – the findings of the GIS preliminary identification and field verification phases of the Wild Rivers Project, Unpublished draft prepared by the Water and Rivers Commission, Government of Western Australia, Perth

Yu, S. W*alangkarr Jirrkaliy Healthy Country Project Final Report*, March 2004, Yuc Pty Ltd, Broome, Western Australia

ACRONYMS

Abbreviation	Meaning
ABS	Australian Bureau of Statistics
ABH	Australian Bush Heritage
ACWA	Aquaculture Council of Western Australia
ALT	Aboriginal Lands Trust
ANZECC	Australia New Zealand Environment Conservation Council
ATSIC	Aboriginal and Torres Strait Islander Commission
AWC	Australian Wildlife Conservancy
CALM	Department of Conservation and Land Management
CAMBA	Chinese and Australian Migratory Bird Agreement
CAR	Comprehensive, Adequate and Representative (reserve system)
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAFF	Department of Agriculture, Forestry and Fisheries
DEH	Department for Environment and Heritage
DoF	Department of Fisheries
DRF	Declared Rare Flora
DSE	Dry Sheep Equivalent
DWT	Dead Weight Tonnes
EMS	Environmental Management System
EMU	Ecosystem Management Understanding
EPA	Environment Protection Authority
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
ESD	Ecologically Sustainable Development
FCT	Fire Control Team
FPC	Forest Products Commission
GIS	Geographic Information Systems
GMS	Gascoyne-Murchison Strategy
IBRA	Interim Biogeographic Regionalisation of Australia
ILC	Indigenous Land Corporation
IMCRA	Interim Marine and Coastal Regionalisation for Australia
IPA	Indigenous Protected Area
IRP	Interim Recovery Plan
IUCN	International Union for the Conservation of Nature
JAMBA	Japanese/ Australian Migratory Bird Agreement
KLC	Kimberley Land Council
KRFMP	Kimberley Regional Fire Management Project
LCDC	Land Conservation District Committee
LFA	Landscape Function Analysis
LGMS	Lower Gascoyne Management Strategy
MAT	Management Action Target
MOU	Memorandum of Understanding
MPA	Marine Protected Area
NAP	National Action Plan for Salinity and Water Quality

NHT	Natural Heritage Trust
NLP	National Landcare Program
NLWRA	National Land and Water Resources Audit
NRM	Natural Resource Management
NSDO	Ningaloo Sustainable Development Office
NWQMS	National Water Quality Management Strategy
OBP	Ord Bonaparte Program
OIC	Ord Irrigation Cooperative
OLWMP	Ord Land and Water Management Plan
ORIA	Ord River Irrigation Area
PGA	Pastoralists and Graziers Association
PLB	Pastoral Lands Board
PPA	Pearl Producers Association
RAP	Regional Assessment Panel
RCT	Resource Condition Target
RP	Recovery Plan
RRFAC	Regional Recreational Fishing Advisory Council
SAP	State Assessment Panel
SCADA	Supervisory Control and Data Acquisition
SEP	Sandalwood Enrichment Program
SIF	Salinity Investment Framework
TAC	Total Allowable Catch
TEC	Threatened Ecological Community
TGM	Total Grazing Management
UCL	Unallocated Crown Land
UMR	Unmanaged Reserve
WAFIC	Western Australian Fishing Industry Council
WARMS	Western Australian Rangeland Monitoring System
WATC	Western Australian Tourism Commission
WCPA	World Commission of Protected Areas
WWF	World Wildlfe Fund
ZCA	Zone Control Authority

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