

12 Public and private conservation of aquatic systems in northern Australia: *threats and opportunities*

Nick Abel, CSIRO Sustainable Ecosystems nick.abel@csiro.au
John Rolfe, Central Queensland University j.rolfe@cqu.edu.au



Photo: Larissa Cordner

CONTENTS

| | |
|---|----|
| 1. KEY POINTS..... | 3 |
| 2. CURRENT STATUS | 4 |
| 2.1. Ecological status..... | 4 |
| 2.2. Values of Aquatic systems..... | 4 |
| 2.3. Who owns and controls the land and water resources? | 6 |
| 3. CURRENT AND POTENTIAL THREATS TO BIODIVERSITY | 8 |
| 3.1 Water storage, abstraction and return flow | 8 |
| 3.2 Climatic change | 10 |
| 4. POTENTIAL INCREASES IN BENEFITS FROM PRIVATE AND PUBLIC CONSERVATION OF AQUATIC SYSTEMS AND HOW TO ASSESS THEM..... | 11 |
| 4.1 Conservation as a relatively safe but contested option..... | 11 |
| 4.2 Identifying priorities..... | 12 |
| 4.3 Monetary valuation of options | 13 |
| 4.4 Deliberative processes | 14 |
| 5. CASE STUDIES | 14 |
| 5.1 Fitzroy River Catchment, Western Australia | 15 |
| 5.2 Daly River Catchment, Northern Territory..... | 15 |
| 6. CONSERVATION GOVERNANCE FOR A HIGHLY VALUED REGION | 16 |
| 7. SUMMARY AND CONCLUSIONS..... | 19 |
| 8. REFERENCES | 20 |

LIST OF FIGURES

| | |
|--|---|
| Figure 1. Aquatic systems values: use values through to non-use values. Source: this report. ... | 5 |
| Figure 2. Land use..... | 7 |
| Figure 3. Indigenous Estate | 7 |

LIST OF TABLES

| | |
|---|----|
| Table 1 Non-market values for three river catchments in northern Australia..... | 6 |
| Table 2. Leasehold tenure arrangements..... | 8 |
| Table 3. Generic costs and benefits of development to be considered..... | 14 |
| Table 4. Conservation actions, potential policy mechanisms, and likely action takers..... | 17 |

1. KEY POINTS

Why is public and private conservation of northern Australian aquatic systems important in the development of land and water resources?

The aquatic systems of northern Australia (rivers, streams, estuaries, lakes, billabongs, marshes, swamps, flats, floodplains and subterranean systems) are highly valued locally, nationally and internationally. Their values include intrinsic worth, a wide range of resource use options, value to future generations, the ecological base they provide for tourism and recreation, and their roles in maintaining ecological functions and as habitats for plants and animals. Northern Australian rivers and wetlands not only require careful conservation to maintain their high values, but they also offer economic opportunities for expansion of tourism, and for conservation as a business.

The current status of public and private conservation and the sustainability of aquatic systems

The majority of northern Australia's aquatic systems are in excellent condition, reflecting the relatively high integrity of the landscape supplying their surface and ground waters. Around two thirds of this is under pastoral tenure, around 30% is Indigenous estate and only some 6% of northern Australia is within public conservation areas (some over-laps with Indigenous estate). Maintaining the high values of these aquatic systems therefore requires the management of sites under a mix of private and public conservation, and the maintenance of the hydrological systems on which the aquatic systems depend.

Potential future pressures and trajectories

There is enough suitable land in northern Australia, and sufficient water to enable further irrigated agricultural development, more mining, tourism and recreation, and aquaculture. The pace and extent of development of those sectors will depend on markets, labour, infrastructure, and technologies, as well access to the land and water resources. Access to these resources is controlled mainly by governments and Indigenous people. Risks, uncertainties and knowledge gaps limit predictions about the potential impacts of development on aquatic systems, and the tradeoffs across generations, sectors and interest groups. More knowledge and better governance and management of aquatic systems, and the landscapes within which they are set, are needed if we are to avoid the severe and extensive degradation of rivers and wetlands caused by storage and over-allocation of water in southern Australia.

How to get sustainable benefits from the development of private and public conservation

Effective governance of aquatic systems and savanna across northern Australia requires a shift of emphasis from the small area of public parks and reserves to the private, mainly pastoral and Indigenous lands and waters that cover most of the region. Here is where the threats and opportunities lie. Setting spatial conservation priorities for the region as a whole, including public and private lands, is a first step, and research is needed to support this and subsequent policy actions. As understanding of climate change and sea level rise grow, we may have to introduce triage into the prioritisation criteria. Meanwhile, other potential conservation strategies include:

- estimation of public preferences for development and conservation
- choice of politically feasible development or conservation options, taking account of equity within and across generations, and the precautionary principle
- water allocation to development and conservation
- voluntary sales of leases for public conservation reserves
- incentives for all or part of a private lease to be put into conservation

- incentives for water point relocation or closure
- incentives for improving biodiversity, feral predator, pest, weed and or fire management
- incentives for conservation agistment to ease grazing pressure at critical times
- incentives for maintaining or establishing connectivity of landscapes or aquatic systems

Auctions are likely to be an economically efficient means for engaging pastoralists and other providers in conservation activities.

2. CURRENT STATUS

2.1. Ecological status

The aquatic systems of northern Australia include its rivers, streams, estuaries, lakes, billabongs, marshes, swamps, flats, floodplains and subterranean systems. According to van Dam et al. (1) there are:

- approximately 62,500 km of riverine length, 76,000 km² of wetlands, including five wetlands of international importance and 70 of national importance covering 26,438 km², 119,000 km² of riparian vegetation including some overlap with wetland areas
- important groundwater-dependent ecosystems
- 'at least 170 freshwater fish species, about 150 waterbird species, at least 30 aquatic/semi-aquatic reptile species, around 60 species of amphibians, and over 100 macroinvertebrate Families' (1) dependent on aquatic systems
- 14 aquatic/semi-aquatic animal species that are threatened, and several other fish, reptile, amphibian and bird species listed as threatened or protected by at least one agency (1), and one endangered ecosystem (associated with discharge from the Great Artesian Basin)
- two wetlands of international importance are artificial impoundments on the Ord River (Lake Argyle and Lake Kununurra)

Most aquatic systems in northern Australia are in good condition, reflecting the relatively high integrity of the savanna landscape supplying their surface waters. Around 90% of the world's tropical savanna in good condition is found in northern Australia (2).

2.2. Values of Aquatic systems

- Northern Australia's aquatic systems are highly valued locally, nationally and internationally. We classified their values as (Figure 1):
- *Direct use values* - these accrue to individuals who use the resource, and can be either extractive or non-extractive. Extractive use values include harvesting of natural resources like fishing (both recreational and commercial). Non-extractive values involve tourism, research and education.
- *Indirect use values* - include values that are gained indirectly from the natural resource, usually through support and protection of other economic activities. Examples include biological support to fisheries, coastal zone protection, and support for Indigenous culture.
- *Non-use values* - to society arise indirectly either through potential future uses or through the knowledge of the presence of the resource. These can be divided into option values, quasi option values, existence values and bequest values. Option values are values for use in the future, existence values are values for knowledge of their presence and bequest values arise from wanting to preserve the public good for future generations. Non-use values can be derived without any actual current human use of the resource.

Production of some values requires water to be ‘consumed’ (diverted and put to another use), but others, such as fishing, use water non-consumptively. Some values, such as products from mines, farms and tourism experiences, are sold. Others are not marketed.

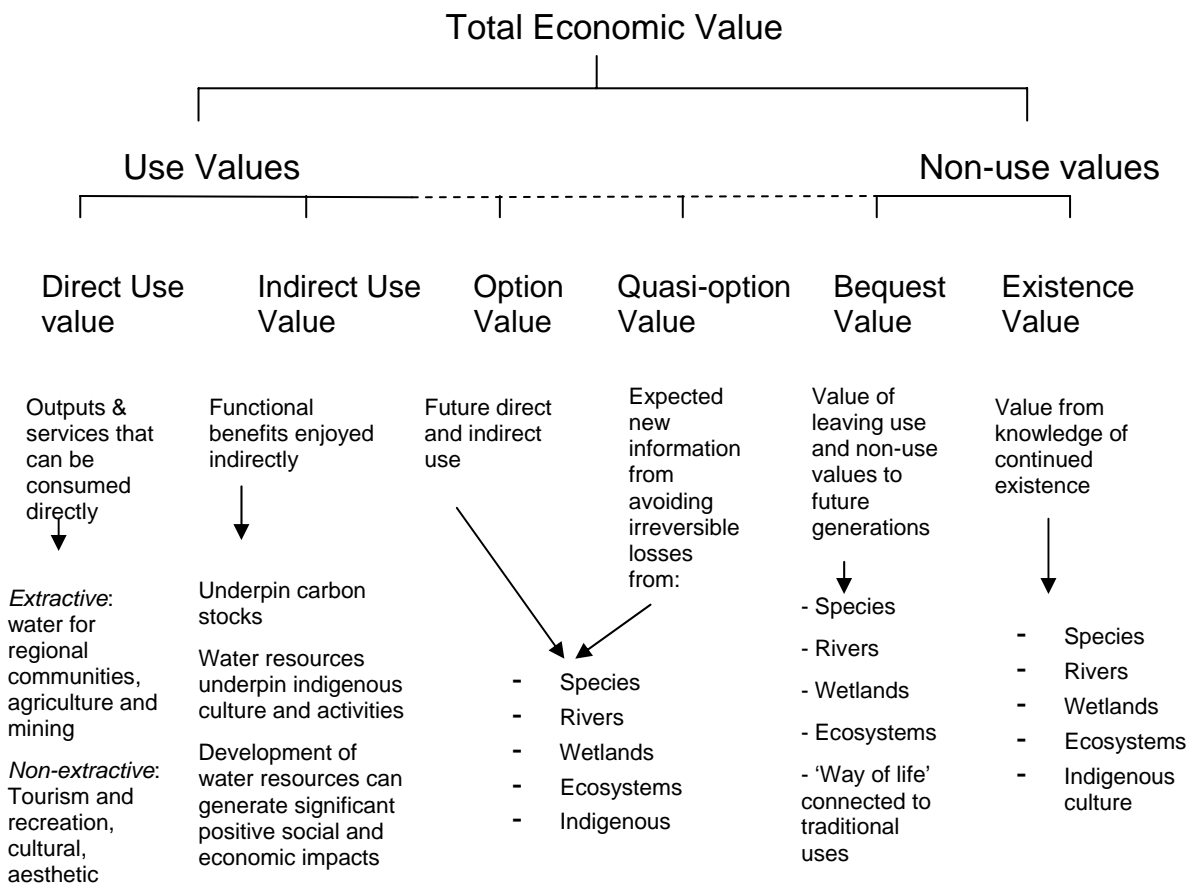


Figure 1. Aquatic systems values: use values through to non-use values. Source: this report.

Stoekl et al. (3) assessed the values of the rivers (essentially the same as our ‘aquatic systems’) of the region, and found them to be important sources of ‘environmental, aesthetic, bequest and option values that exist when the rivers are not being “used” – or used up.’ (p. vi). They also noted the direct and indirect use values accruing to Indigenous people for cultural purposes, fishing, recreation, to residents, and to the fishing, agriculture, tourism and mining sectors. Altman et al. (2009, chapter 7 this report) note the importance of water and aquatic systems to Indigenous people for the customary harvest of wildlife and plants and for agricultural and pastoral operations, commercial art, nature and cultural tourism, safari/conservation hunting, plant propagation, commercial wildlife and bush foods ventures. Indigenous people are also employed in mining, pastoral, tourism and other industries.

Building on the work of Stoekl et al. (3), Straton and Zander (4) used choice modelling to quantify non-market values for three river systems in northern Australia: the Daly River in the Top End of the Northern Territory (NT), the Fitzroy River in the Kimberley region of Western Australia (WA), and the Mitchell River in northern Queensland (Qld). A survey setting was used to present householders in each catchment area and two capital cities in Australia with future development options for each catchment. The development options were described in terms of:

- Area of floodplain in good condition

- Quality of the river for recreational fishing
- Condition of waterholes important to Aboriginal people
- Income from irrigated agriculture per year

The results are summarised in Table 1, and show the estimated values per household for each attribute compared to attributes in poor condition.

Table 1 Non-market values for three river catchments in northern Australia

| Medium area floodplain in good condition | Large area floodplain in good condition | Medium quality river for rec. fishing | High quality river for rec. fishing | Medium condition waterholes | Good condition waterholes | Medium income from irrigated agric. | High income from irrigated agric. |
|--|---|---------------------------------------|-------------------------------------|-----------------------------|---------------------------|-------------------------------------|-----------------------------------|
| Fitzroy catchment sample | | | | | | | |
| \$121.03 | \$146.08 | \$223.09 | \$222.95 | \$228.36 | \$314.58 | * | * |
| Fitzroy catchment Indigenous sample | | | | | | | |
| \$122.11 | \$118.97 | \$200.50 | \$223.65 | \$264.36 | \$347.51 | * | * |
| Fitzroy Cities sample (Melbourne, Perth) | | | | | | | |
| \$30.16 | \$132.74 | \$70.62 | \$143.33 | \$141.77 | \$281.32 | \$122.04 | \$87.60 |
| Daly catchment sample | | | | | | | |
| \$69.26 | \$128.81 | \$191.15 | \$243.81 | \$178.63 | \$266.89 | * | * |
| Daly catchment Indigenous sample | | | | | | | |
| \$115.86 | \$156.06 | \$163.72 | \$344.75 | \$329.16 | \$429.42 | ** | ** |
| Daly Cities sample (Darwin, Sydney) | | | | | | | |
| \$63.07 | \$176.83 | \$92.90 | \$156.42 | \$117.98 | \$204.80 | \$71.57 | \$28.13 |
| Mitchell catchment sample | | | | | | | |
| COST statistically insignificant from zero | | | | | | | |
| Mitchell catchment Indigenous sample | | | | | | | |
| Failed to converge | | | | | | | |
| Mitchell Cities sample (Brisbane, Canberra) | | | | | | | |
| \$74.04 | \$203.74 | \$107.31 | \$174.50 | \$131.82 | \$277.91 | \$146.52 | \$130.60 |

* Values failed to converge

Source: (4).

Other chapters in this report describe the values drawn from aquatic systems associated with Indigenous uses (Altman et al., this report), irrigated agriculture (Webster et al., this report), mining (Brereton et al., this report), tourism and recreation (Clark et al., this report), and commercial fishing and recreation (Clark et al., this report). All can of these uses and values have negative impacts on aquatic systems, and all need to be considered in water planning (Ward 2009 Chapter 28).

2.3. Who owns and controls the land and water resources?

Land uses are:

- leasehold pastoralism, the dominant land use on approximately 66% of the region. Some of this land may also be under Native Title
- Aboriginal freehold land, covering about 30% of the region

- parks and reserves, said to cover some 6% of the region. Most conservation lands are managed by government agencies but a small number are run by charitable trusts (Garnett et al. in press, via Alex Kutt, pers. comm.). We assume some of this area overlaps with Indigenous Estate, some of which is Aboriginal Freehold, some Native Title (Figure 2 and Figure 3).
- dryland, irrigated cropping, mining and defence lands, cover less than 2% of the area of northern Australia.

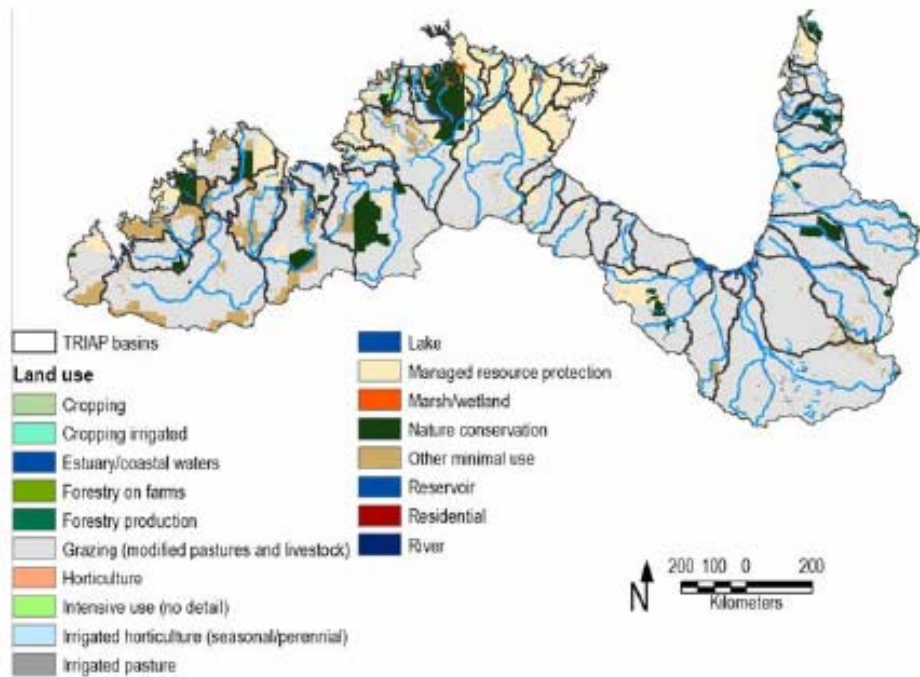


Figure 2. Land use
 Source: (3).

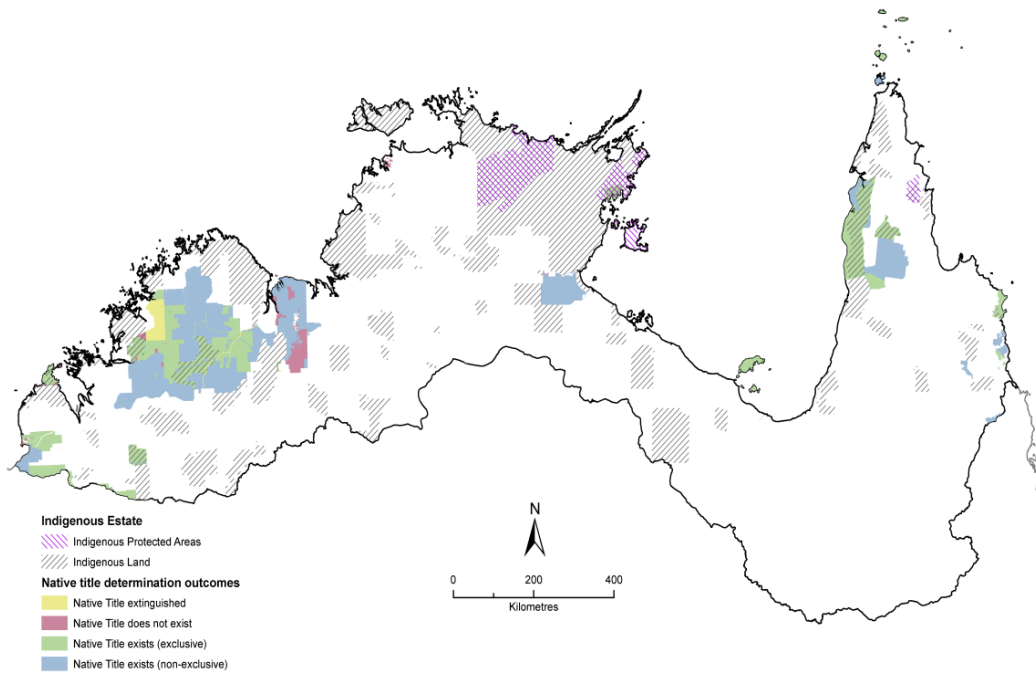


Figure 3. Indigenous Estate
 Source: Australian Government Department of the Environment, Water, Heritage and the Arts; National Native Title Tribunal.

Approximately two thirds of the land that is under pastoral tenure is subject to lease conditions which vary between jurisdictions (Table 2).

Table 2. Leasehold tenure arrangements

| Tenure | Authority to change to non-pastoral use | Lease term & length |
|--------------------|---|--|
| Western Australia | Pastoral Lands Board | Term leases only (maximum length 50 years). |
| Queensland | Minister | Perpetual & term (term maximum length 50 years). |
| Northern Territory | Minister | Perpetual and term (term maximum length 25 years). |

Source: adapted from (5)

Pastoralists thus control a high proportion of the catchments on which the aquatic systems depend, and have direct control over significant areas of the aquatic systems themselves. Governments can influence pastoral management by changing lease conditions, but this is more likely to be effective if it enables rather than hampers innovation (6). There is a need and a good potential for developing incentives that would benefit both pastoralists and conservation. It is currently financially worthwhile for some pastoralists (including pastoral companies) to abstract groundwater to irrigate fodder crops. This can affect stream flows and the persistence of water holes and wetlands. Location, volume and timing of abstraction can all affect this, and efficient trade-offs are possible (Cresswell et al.; this report). Access to water depends on water planning and supporting legislation and policies (Ward, chapter 28).

Much of the rest of the region is Indigenous Estate (Figure 3), some freehold, some Native Title. Indigenous people often see access to, and ownership of, water as issues of human rights. Their rights to water are contested and unclear. Possible tensions between commercial allocations and Indigenous people's statutory customary use rights under the Native Title Act 1993 (NTA) need to be recognised and ameliorated. The extent of Indigenous access to and control over water may affect their capacity to manage land for conservation as an income source.

3. CURRENT AND POTENTIAL THREATS TO BIODIVERSITY

A threat to biodiversity is an opportunity for conservation. Current and potential threats and opportunities are land use, water storage, abstraction and pollution, feral pests and weeds, and climatic change. Although the others are significant, we limit our focus to threats related directly to water, while acknowledging that feral pests and weeds affect aquatic systems too, and are and should be managed.

3.1 Water storage, abstraction and return flow

There is enough suitable land in northern Australia, and sufficient water to enable further irrigated agricultural development (Cresswell et al., Wilson et al., Webster et al.; this report), and more mining, tourism and recreation, and aquaculture. The pace and extent of development of those sectors will depend on markets, labour, infrastructure, and technologies, as well access to the land and water resources. Access to these resources is largely controlled by governments and Indigenous people. Risks, uncertainties and knowledge gaps limit predictions about the potential impacts of development on aquatic systems, and the tradeoffs across generations, sectors and interest groups. More knowledge and better governance and management of aquatic systems, and the landscapes

within which they are set, are needed if we are to avoid the severe and extensive degradation of rivers and wetlands caused by storage and over-allocation of water in southern Australia.

Very little of northern Australia is farmed intensively now, which is the primary reason for the good condition of its savanna and aquatic systems. Even with a fivefold expansion of irrigated agriculture, as modelled in Webster et al (this report), from the current 34,000 ha to 171,000 ha, only *ca* 0.13% of the region would be under irrigated production. This is unlikely to be exceeded over the next decade, but climatic and market changes, population increases, new technologies and other factors could drive larger long term increases in intensive agriculture. This is one reason to address threats from agricultural intensification seriously. Another is because local agricultural, mining and urban developments all impact negatively on adjacent aquatic systems, and thus on specific residential, tourism, conservational and recreational interests. An awareness of these impacts and building the capacity to estimate them is a necessary foundation for effective water planning (Ward, this report, chapter 28). A third reason is that it is very costly, and often ecologically impossible, to reverse degradation of ecosystems, as we are learning in the Murray Darling Basin (MDB), so potential degradation of even part of an ecosystem should be appraised carefully, and the likelihood of reversibility assessed. Finally, the good condition of the region's aquatic systems give us time to build the effective environmental and water governance arrangements we now wish we had had in time to conserve the MDB.

The rest of this section draws mainly on these chapters in this report: Cresswell et al.; Wilson et al.; Pusey & Kennard; and Kutt.

Irrigated agricultural development in the region is likely to take two forms: expansion of existing dam-based irrigation; and irrigation relying on bores. The potential for large new dams is generally low because most rain falls near the mouths of the rivers, where dams cannot be built, rather than upstream, where most dams would not catch enough water to justify their cost. Aquifers are therefore the most widespread and perhaps best available sources of irrigation water (Cresswell et al., this report).

The aquatic systems of the region, their plants and animals, the relationships among them, and their abundance, have all been shaped by the river flow regimes. These can be affected by either dams or bores. A flow regime is the volume of flow, the season in which it happens, how often it happens, how long it lasts, and how variable it is. A change in any of these affects the abundance and mix of plants and animals. Aquatic systems affected by changes in flow regimes include rivers, streams, estuaries, lakes, billabongs, marshes, swamps, flats, floodplains and sub-terrestrial systems. All are important habitat for plants and animals (fish in particular) that are valued by Indigenous people, other residents, visitors and to the tourism and commercial fishery sectors (see appropriate chapters in this report).

Freshwater flows to the ocean increase growth rates of fish and prawns, probably because of the nutrients carried by floodwaters. Faster growth rates lead to better survival of young fish. Stream flows enable mature fish of species such as barramundi to migrate downstream to spawn in estuaries, and the young fish to migrate upstream where they feed and grow until they return to spawn. Fished species that depend on freshwater flow include mud crabs, banana, tiger and endeavour prawns, barramundi, king threadfin, grunter, mackerels and sharks. Other species whose abundance depends on freshwater flows are prey for fisheries species, so reductions in flow can affect fish through declines in spawning, recruitment, survival and food supply (Pusey & Kennard; this report).

Dams

A natural flow regime in northern Australia is flooding during the wet, declining to low or zero surface flows after the rains end. Dams are built to store floodwater, and release it during the dry when crops or towns need it: seasonality is reversed. Dams also reduce the volume of flow by storing

and diverting it so more evaporates. By storing water, dams also reduce the frequency, duration, and variability of floods. Dams and weirs impact on aquatic systems by impeding movements of aquatic organisms, and blocking flows of sediments and nutrients to estuaries, but principally by transforming flow regimes. The impacts of damming the Ord River (Lakes Argyle and Kununurra) and diversion of the Barron River into the Mitchell River for the Mareeba-Dimbulah Irrigation Scheme are already evident. Lake Argyle has been declared a Ramsar site in recognition of its importance as a wetland and bird habitat. It also supports commercial (Clark et al.; this report) and recreational fishing. Lake Argyle contributes positively to tourism and recreation. An investigation of the net benefits of the Ord and Kununurra Dams, their impacts on aquatic systems, and on Indigenous and conservation interests, was (unfortunately) beyond the scope of this paper.

Groundwater

Abstraction of water from aquifers for irrigation or urban supply can also affect river flow, because it can lower the water table. River flows, aquatic systems (and terrestrial ecosystems) in the region depend on aquifer levels during the dry season. Few rivers in the region have perennial flow, but many have waterholes in their beds that persist through the dry. A fall in water table can end perennial flow and dry out water holes. Both are important as dry season refuges for plants and animals, including fish, and consequently support Indigenous, conservation, recreational and tourism interests (4). The distance of a bore from the river it feeds, together with the volume abstracted, determine the flow and the persistence of water holes, thus the impacts of abstraction on those interests. Transmissivity of aquifers varies with rock type, and there is also spatial variation within an aquifer. Determining these critical distances and volumes for different aquifers are prerequisites for estimating the trade-offs among agricultural, pastoral and other interests, and for developing Water Plans and allocation rules and other institutional arrangements (chapters 14 – 23).

Agricultural run-off

Agricultural runoff can carry pollutants that potentially harm aquatic systems (7). They include pesticides, herbicides and heavy metals that can affect growth and development of aquatic organisms, their dispersion behaviour and reproduction. For example, one rainfall event in eastern Queensland transported an estimated 470 kg of the herbicide Diuron into a weir. Residues of other herbicides from cane lands, including Amtryn, Atrazine, Hexazinone and 2,4-D, were also detected. Some of the biocides used in the Darling catchment in the 1970s were still detectable a decade later. Clearing of riparian vegetation and loss of wetlands can reduce their buffering effects and enhance the ability of runoff to transport pollutants (Pusey and Kennard; this report). Oliver and Kookama (8) rated pesticide mobility and toxicity risks on the Ord Irrigation Area under various levels of soil loss and soil organic carbon. Risk ratings ranged from very low to very high, and they recommended that Atrazine, Chlorpyrifos, Chlorothalonil, Cypermethrin, Diuron, Endosulfan, Glyphosate, Mancozeb, Trifluralin and Pendimethalin use be monitored.

3.2 Climatic change

This section summarises Pusey and Kennard; (this report).

Although there is substantial uncertainty about climatic change, there are likely to be fewer, but more intense rainfall events. This means enhanced runoff from each event and larger floods but of shorter duration, and perhaps less aquifer recharge, which may also lead to reduced stream flows. Larger floods may erode sediments and change channel form. Predicted changes in hydrology are expected to vary greatly across northern Australia. A 2-4°C rise in air temperature is predicted for tropical regions by 2100. Evaporation rates would increase significantly and this may reduce the persistence of pools in intermittent rivers and wetlands that are important dry season refuges for many aquatic species. Decreased dissolved oxygen concentrations, a function of temperature as well

as oxygen availability, may impact on these species. Changes this fundamental would radically affect the species composition and functioning of aquatic systems.

There is little doubt that sea levels are already rising, but there is uncertainty about the future magnitude of change. The inundation of freshwater wetlands by the sea may occur over a vast spatial scale. If the severity of monsoonal storms increases as expected then the potential area inundated by storm surges is likely to increase accordingly. This may further impact coastal wetlands and floodplains. Such changes would impact greatly on aquatic systems.

Although there is some understanding about the directions of causal relationships (i.e. positive or negative) among water abstraction and storage, water flows and aquatic systems, quantifying them is difficult. This is because some of the relationships are lagged (for example changes in erosion-sedimentation regimes), some have thresholds that mark switches to another state (eutrophication, for example) that may not be readily reversible, some impacts are cumulative, and most impacts interact with each other. Climatic change adds further uncertainty because its trends, magnitudes and thresholds are not known. However, if irrigated agriculture is increasing its usage of water as climatic change happens, these two impacts will interact and magnify the consequences for aquatic systems.

Conservation has been a low land use priority in the past, as reflected in the small areas conserved. This has been justified by the good condition of the wetlands, and the relatively intact savanna. The conservation priority may grow if aquatic systems begin to degrade. If sea levels also rise significantly, and if this is coupled with intensification of land use, then conservation priorities will shift in space as well as time, requiring flexibility in conservation activities. We develop ideas about adaptive conservation in section 4.

4. POTENTIAL INCREASES IN BENEFITS FROM PRIVATE AND PUBLIC CONSERVATION OF AQUATIC SYSTEMS AND HOW TO ASSESS THEM

4.1 Conservation as a relatively safe but contested option

Our world grows increasingly uncertain as its population increases, competition for land and water grow, fossil fuels are used up, and our climate changes. We do not know how our ecosystems will respond to the increasing shocks they receive. Some changes may be irreversible.

Intact aquatic systems carry high bequest values. Such systems - once widespread, now increasingly rare - can be enjoyed by future generations, climatic change permitting. Intact aquatic systems confer a comparative economic advantage on the region and Australia for the same reason – their scarcity elsewhere enables Australia to attract tourists readily and provide a unique outdoor experience. But in times of uncertainty it is the high option values of the intact aquatic systems that count for the most. Compared with landscapes transformed by agricultural development, intact aquatic systems have very high option values – no irreversible change has happened, and the option could be reserved until a highly attractive option emerges. Meanwhile conservation is a low cost option that can be enjoyed for its other values. Again, this benefit is contingent on climatic change, but if the asset is lost the regret is less than if its loss had been caused by costly infrastructure or irreversibly changed land or aquatic systems.

Concerns about unanticipated consequences of development have led to different frameworks being suggested to avoid unknown risks of future development. The Safe Minimum Standard (SMS) Rule (9) was developed as an alternative decision framework to be invoked when environmental assets face some risk of extinction. When the SMS rule is invoked, the presumption is that the environmental species at risk has 'trump' status. The burden of proof to change this presumption, typically requiring high levels of scientific certainty, falls on proponents of development. The Precautionary Principle is a similar but more general proposition. It suggests that where there is the potential for severe or

irreversible environmental damage, particularly when there is a lack of scientific certainty about outcomes, decision makers should be cautious to avoid future losses. The principle suggests that decision makers be proactive to avoid future risks even when scientific certainty exists (10) (11). Under the similar 'strong sustainability' approach, resource use and environmental impacts are constrained because of limited ability to substitute different forms of capital for any rundown in resource stocks (12).

There are three key arguments that are often used to justify a precautionary approach to terrestrial and aquatic resources in northern Australia:

- *the pristine argument* is that Australia has almost all (90%) of the world's tropical/subtropical savanna systems in good condition, as these landscapes have been extensively modified or degraded in other countries (2). Australia therefore has an international obligation to preserve these assets.
- *the risk argument* is that more intensive resource use, such as intensive agriculture, has the potential to degrade savanna and aquatic systems, as outlined above. Because this risk is established, it can and should be avoided.
- *the uncertainty argument* is that ecosystem functioning in northern Australia is complex, and characterised by thresholds and potential irreversible impacts. Meanwhile our very limited knowledge makes it difficult to predict impacts in time and space. Because we are uncertain, we should not proceed in the face of uncertainty.

The precautionary principle is said to underpin the *Wild Rivers Act 1995* in Queensland. Its purpose is to provide a high level of protection from new development activities that have the potential to degrade the wild rivers' natural values. The legislation only applies to rivers in natural or near natural condition, and specifies what types of new development might be allowed and where they can occur. Under the legislation, river catchments are specified as high-preservation areas (the area one kilometre either side of all streams plus special off-stream areas such as wetlands) and preservation areas (the remainder of the catchment). The effect of the Act is to restrict development that would impact on the river basin, with many current activities such as agriculture, fishing and Indigenous uses still allowed to occur.

Seven of the rivers declared under the *Wild Rivers Act 1995* in Queensland are in northern Australia: the Archer, Gregory, Lockhart, Morning Inlet, Settlement, Staaten and Stewart rivers. Other areas under consideration in Cape York Peninsula include the Jardine, Ducie, Wenlock, Watson, Holroyd, Coleman, Jackey Jackey, Olive-Pascoe and Jeannie River basins¹. These listings have been actively pursued by the Wilderness Society in Queensland, but have been opposed by some Indigenous people, particularly Noel Pearson (Altman et al., this report). Pearson has argued that the legislation trumps control over Indigenous land, and will restrict many opportunities for Indigenous people to pursue economic development and generate welfare and social improvements. Pearson proposes that the restrictions occur through both the intent of the legislation (to preserve the wild rivers) and the process to gain approval for any development.

4.2 Identifying priorities

The CAR system (comprehensive, adequate and representative) is a widely used method for prioritising land for conservation, whether in a public or private reserve, or in deciding where conservation management is a priority on production lands (13). Most jurisdictions are at least aware that it can be used for prioritising public reserves, and the National Reserve System is prioritised this way. CAR can be applied to intensively farmed landscapes or relatively intact rangelands (5). The landscape is classified, along with its wetlands, according to how it was thought to be configured before establishment of water points, clearing, drainage or inundation. This classification can be

¹ See <http://www.nrw.qld.gov.au/wildrivers/> (accessed 16th October 2009).

applied to bioregions, vegetation types, or another classification type. It is assumed, often unjustifiably, that suites of species will be conserved if a portion of each landscape category is conserved. Priorities for conservation increase with the extent of water points, clearing, drainage or inundation on each category of landscape type. The greater the area transformed, the higher the conservation priority ('comprehensiveness'). Measures of vulnerability, such as the small sizes of particular patches, can be added to raise the priority ('adequacy'). If there is variation within a landscape category, priorities are adjusted to include the range of variation ('representativeness'). Multi-criteria analysis is applied to derive a score for each occurrence of each landscape category, and connecting links. Anytime a site is added to or removed from the system, the priorities of all other elements change because the priority scores are relative.

This simple approach is useful because we know little about the habitat requirements of individual species, their resource requirements, movements and interactions with other species. The static approach can be extended to include the prioritisation of connectivity between occurrences of landscape units that would otherwise be isolated, and the species within them vulnerable to extinction. Connectivity is critically important in the conservation of aquatic systems, but because it is water that establishes connectivity, it is more easily observed.

There is therefore a case for prioritising the conservation of aquatic systems across all jurisdictions of the region with an approach similar to the use of a CAR filter. If however, the priorities are to be proactive rather than reactive, vulnerability should take account of land suitability for arable agriculture – not just irrigation. We know how to do this. Although we do not know what the impacts of climatic change will be, but by minimising the effects of agricultural development on conservation we may reduce climatic impacts somewhat. We might also apply triage to aquatic systems that are highly likely to be inundated, focussing the bulk of conservation effort on less vulnerable sites. This concept could in fact be applied to an otherwise conventional CAR approach, in that landscape occurrences that have little chance of being well managed should probably not be conserved even though their conservation priority may be high.

4.3 Monetary valuation of options

Economic evaluation normally involves the consideration of the costs and benefits that flow from different resource options. This information can then form an input into decision frameworks such as multi-criteria analysis, which is used widely for estimating and ranking conservation opportunities which are, by definition, un-marketed. Monetary values can be estimated, subject to many caveats. In Table 1 we presented Straton and Zander's choice modelling valuation of aquatic systems and irrigated agriculture. This approach is costly. A less expensive way is to transfer environmental values from one or more existing case studies to a target site of interest (14) (15). Values can be transferred across time, space, populations, and sometimes from one type of environmental asset to another (16) (17). The biggest weakness is that the contexts in which the valuation surveys were set is not transferable. Sources of values that could, with care, be potentially transferred, include:

- estimated values to protect an area at Kakadu from mining. Results showed that the public held significant values to preserve the iconic site, with estimates of value over \$100 million (18).
- estimated recreation value of visitors to the Fairbairn Dam in central Queensland, using the travel cost method. The value was estimated at \$5,630 per trip, or \$105.79/day (19).
- estimated values for holding water in reserve in the Fitzroy Basin in central Queensland, neither allocating it specifically to agricultural use nor reserving it for the environment. The annual value of maintaining options for future use held by Brisbane households were assessed from \$1.90 to \$6.12 (in 2007 dollars) per 1% of water reserves (20).

- estimated value for protecting healthy soils, waterways and vegetation in Queensland, including the Fitzroy region in central Queensland. Values per household were estimated at \$3.72, \$5.80 and \$2.88 for each 1% improvement in soils, waterways and vegetation respectively (21).
- estimated values of Brisbane and Rockhampton Indigenous residents for better protection of aboriginal cultural heritage sites in the Fitzroy Basin in central Queensland. Results showed that Rockhampton Indigenous residents had strong preferences for higher levels of protection (\$3.69 in 2007 dollars for each 1% improvement in protection), but that the non-Indigenous population had positive values for only small increases in protection (17).

4.4 Deliberative processes

Monetary valuation can use revealed preferences, as in travel cost methods, or stated preferences, where respondents are asked to state the amounts they would be prepared to pay for an option. Stated preferences suffer the obvious weakness that respondents do not actually have to hand the money over, and are not therefore constrained by their budgets. Stated preferences also assume an often unjustifiably high level of knowledge about an environmental issue. Spash (22) also points out the importance of equity to many people involved in collective decisions, and describes the mismatch between the assumed individualism of respondents and their focus on money, and their actual behaviour (23). He has developed and tested deliberative group processes that combine monetary valuation with processes of group discussion, reflection and information-gathering. He contrasts the difference between sampling individuals randomly to obtain their person preference, and seeking the considered preferences of a group that through the deliberative process has come to see itself as representing a common interest. His empirical study showed distinct differences in the values obtained through individual compared with group processes.

It is already costly to obtain valuations of conservation options from individual surveys, and the results are contestable. Benefit transfer remains the least cost option, but its estimates will always be regarded suspiciously. It would be much more costly to get robust estimates from deliberative processes that represented a fair range of interest groups, but such processes may be a necessary foundation for informed decisions on conservation or other public policy choices.

5. CASE STUDIES

Both case studies match the summary of information about the condition and threats of the catchment in van Dam et al. (1), with the information about values for maintaining assets in good health derived from Straton and Zander (4). Decisions about development proposals (and major policy changes such as preservation options) should be based on an underlying assessment of the costs and benefits involved. A summary of the key impacts to consider is provided in Table 3.

Table 3. Generic costs and benefits of development to be considered

| | Positive impacts | Negative impacts |
|----------------|---|--|
| Regional Level | Additional production and income | Potential impacts on businesses relying on pristine environment (ecotourism) |
| | Social and Indigenous benefits from increased income and employment | Cultural heritage impacts |
| | Some biodiversity benefits from improved management | Regional non-use values for the environment |
| National level | Wider benefits of increased production and income | Community non-use values for environmental impacts and future risks |

| | | |
|--|--|--|
| | Community values for maintaining regional and Indigenous populations | Community non-use values for cultural heritage impacts |
|--|--|--|

5.1 Fitzroy River Catchment, Western Australia

The Fitzroy River Catchment in Western Australia is approximately 94,000 km² in area and has had an average annual discharge of 7,000 GL since the 1960s, the highest in the state (1). Significant ecological assets include 8,145 km of riverine length and 8,410 km² of riparian areas supporting significant wetlands (6,559 km²) as well as biodiversity assets and threatened species (1). Four aquatic or semi-aquatic species listed as threatened have been identified in the entire Fitzroy Basin. Land use in the region is dominated by low intensity grazing, although there has been some cropping in the past at Derby and Camballin². There is potential for a substantial increase in irrigated agriculture by drawing on underground reserves, but there have also been calls to protect ecological and cultural values of the Fitzroy River from development (1).

Application of a cost-benefit analysis framework to proposals for development would compare the benefits of additional production (increased profits and social benefits of higher employment) against the costs involved (environmental and cultural impacts). If irrigated agriculture is established with limited access to groundwater and clear planning guidelines to minimise ecological impacts, it could be expected to have some impact on riparian areas, but little impact on wetlands, waterholes, biodiversity assets, threatened species or recreational fishing. As the scale of development and access to water reserves increases, the level of environmental and cultural impacts can also be expected to increase. Here the costs are estimated, assuming that new developments would impact on 50 km² of riparian areas (0.5% of riparian area in the basin), and that other environmental impacts are minimised. Application of the values and survey response rates generated by Straton and Zander (4) indicates that the value of those riparian assets per household is less than \$0.01 for 26.3% of Fitzroy catchment households, not determined for 98% of Fitzroy Indigenous households, and \$1.94 for 33.1% of Perth and Melbourne households. If the benefits of development, including community values for supporting rural communities and Indigenous employment, outweigh these costs, there is a case for development to occur.

5.2 Daly River Catchment, Northern Territory

The Daly River Catchment in the Northern Territory is located about 200 km south of Darwin, and is approximately 52 600 km² in area (1). There are large underground aquifers which support both a perennial flowing river system and a developing irrigation industry. Significant ecological assets include 4,860 km of riverine length and nearly 3,000 km² of riparian areas supporting significant wetlands (1,940 km²) as well as biodiversity assets and threatened species. Six aquatic or semi-aquatic species listed as threatened have been identified in the entire Daly Basin (1). There are ten conservation reserves or parks in the catchment, with species well represented across the parks. Approximately 46% of the basin is used for agricultural purposes, with pastoral activities dominating the land use (45.4% of the area). There is potential for a substantial increase in horticulture by drawing on underground reserves, and the Northern Territory Government has been planning for future agricultural development in the catchment.

² Rice and sorghum were grown on about 20-30 km² with water from the Camballin Weir from the 1950s to 1983, when flooding destroyed water control infrastructure.

Application of a cost-benefit analysis framework to proposals for development would compare the benefits of additional production (increased profits and social benefits of higher employment) against the costs involved (environmental impacts). If irrigation by horticulture increased by ten times, from 26 km² to 260 km², with clear planning guidelines to minimise ecological impacts, it could be expected to have some impact on riparian areas, but little impact on wetlands, waterholes, biodiversity assets, threatened species or recreational fishing because irrigation water can be sourced from underground supplies. Assuming that 20% of new irrigation development would involve riparian areas means that 46.8 km² or 1.6% of existing riparian areas would be developed. Application to the values and survey response rates generated by Straton and Zander (2009) indicates that the value of those riparian assets per household is approximately \$1.84 for 26.7% of Daly catchment households, \$1.27 for 100% of Daly Indigenous households, and \$3.6 for 34.1% of Darwin and Sydney households. If the benefits of development, including community values for supporting rural communities and Indigenous employment, outweigh these costs, there is a case for development to occur.

6. CONSERVATION GOVERNANCE FOR A HIGHLY VALUED REGION

A change in conservation focus from a small area of public parks and reserves to embedding conservation activities across private and indigenous lands will require development of governance structures. Governance is the institutions (laws, regulations, e.g. land tenure, water entitlements), policies (investments, disinvestments, incentives, taxes, information, etc.) and the organisations for implementing them. Conservation governance for the region is much broader than just national park, conservation reserve, fauna, flora and biodiversity protection laws. It also includes land and water legislation, regulations and policies, and it covers local government, Territory and State as well as Commonwealth laws, regulations and policies. Conservation governance also needs to invest much more in conservation on private land if it is to make more than a trivial contribution to conserving the aquatic systems and savannas of the region. In addition it should become able to function across jurisdictions, but we will avoid that challenge in this chapter. Conservation governance does need to be able to resolve actual and potential conflicts between conservation and sectors such as irrigated agriculture and fodder production, mining and aquaculture. It should also be able to foster synergies between conservation and extensive pastoralism, commercial fishing, Indigenous fishing, hunting and gathering, Indigenous land and water management, Indigenous art, and tourism and recreation. Several of the mechanisms in Table 4 would promote synergies.

Table 4. Conservation actions, potential policy mechanisms, and likely action takers

| Action | Potential mechanisms | Action expected from | Private land | Public reserve |
|---|--|---|------------------------------|----------------|
| | | | | |
| Prioritisation of conservation units (e.g. bioregions) | Comprehensiveness, adequacy and representativeness | Government departments or research bodies | √ together form a CAR system | |
| Research and the provision of information | Public and NGO funding | Universities and research organisations, NGOs, government departments | √ | |
| Estimation of public preferences for development and conservation | Deliberative processes, or surveys, to provide public preference information OR Formal political processes | Public and interest groups | √ | |
| Choice of politically feasible development or conservation options, taking account of equity within and across generations, and the precautionary principle | Formal political processes, lobbying | Governments, lobbyists | √ | |
| Water allocation to development and conservation | Water rights and water planning process – both withholding and granting of allocations in line with conservation impacts | Governments and stakeholders, lobbyists | √ | √ |
| Lease purchases for conservation | Public conservation funding OR NGO funding | Conservation department OR NGO | √ | |
| All or part of a private lease put into conservation. | Lease owner remains in residence as manager. Conservation agreements possibly auctioned. Most likely NGO funded. | | √ | |
| Water point relocation or closure | Conservation agreement offered by a government or | Pastoralist or farmer | √ | |

| | | | | |
|---|--|--|---|---|
| | NGO. Potential for auction. Possible changes in lease conditions required. | | | |
| Feral predator, pest, weed and or fire management | Outcome contract offered by a government or NGO. Potential for auction. | an NGO, an Indigenous group, pastoralist or other private provider | √ | √ |
| Conservation agistment to ease grazing pressure at critical times | Contract offered by a government or NGO. Potential for auction. | Pastoralist | √ | |
| Maintaining or establishing connectivity of landscapes or aquatic systems | Conservation agreements linking multiple leaseholders. Potential for auction but more complex. | Pastoralists | √ | |

Source: much adapted from (5).

Our emphasis for conservation is necessarily upon private pastoral and Indigenous lands, because that is where the greatest threats and opportunities are. The dichotomy between conservation and development that exists in much of southern Australia is not an appropriate model for the north. Integration of conservation with pastoral and indigenous lands will require more focus on incentives rather than regulation, as most of the desirable on-ground actions are well beyond duty of care. On these lands it is likely that many conservation outcomes can be achieved more cost-effectively by private and Indigenous managers motivated by incentives than by public employees. Pastoralists and indigenous people already live on the land and have much of the knowledge and skills required for conservation work. The challenge for policy makers will be to craft governance structures and incentive mechanisms that allow more seamless integration between conservation and production activities in the north.

7. SUMMARY AND CONCLUSIONS

The aquatic systems of northern Australia are in excellent condition, reflecting the relatively high integrity of the landscape supplying their surface and ground waters. They are highly valued locally, nationally and internationally for their intrinsic worth; wide range of resource use options; value to future generations; the ecological base they provide for tourism and recreation; and their roles in maintaining ecological functions and as habitats for plants and animals.

Approximately two-thirds of northern Australia is under pastoral tenure, around 30% is Indigenous estate and only some 6% is within public conservation areas. Maintaining the high values of these aquatic systems therefore requires the management of sites under a mix of private and public conservation, and the maintenance of the hydrological systems on which the aquatic systems depend.

Northern Australia has enough suitable land and sufficient water to enable further irrigated agricultural development, more mining, tourism and recreation, and aquaculture. Risks, uncertainties and knowledge gaps limit predictions about the potential impacts of development on aquatic systems, and the tradeoffs across generations, sectors and interest groups. More knowledge and better governance and management of aquatic systems, and the landscapes within which they are set, are needed if we are to avoid the severe and extensive degradation of rivers and wetlands caused by storage and over-allocation of water in southern Australia.

Effective governance of aquatic systems and savanna across northern Australia requires a shift of emphasis from the small area of public parks and reserves to the private, mainly pastoral and Indigenous lands and waters that cover most of the region. Here is where the threats and opportunities lie. Setting spatial conservation priorities for the region as a whole, including public and private lands, is a first step, and research is needed to support this and subsequent policy actions. As understanding of climate change and sea level rise grows, we may have to introduce triage into the prioritisation criteria. Conservation governance, if implemented, is most likely to succeed by using an incentive-based approach, a reflection of the largely private management of conservation assets.

8. REFERENCES

1. van Dam, T, Bartolo, R and Bayliss, P. Chapter 2 – Identification of ecological assets, pressures and threats. Sub-project 2 of Australia's Tropical Rivers – an integrated data assessment and analysis . [book auth.] R Bartolo, P Bayliss and R van Dam. *Ecological risk assessment for Australia's northern tropical rivers*. s.l. : Land & Water Australia, 2008.
2. Woinarski, J, et al. *The Nature of Northern Australia: Natural values, ecological processes and future prospects*. Canberra : ANU Press, 2007.
3. Stoekl, N, et al. *An assessment of the social and economic values of Australia's tropical rivers*. . Canberra : CSIRO, James Cook University. Land and Water Australia, 2006.
4. Straton, A and Zander, K. *The value of Australia's tropical river ecosystem services*. s.l. : CSIRO, Tropical Rivers and Coastal Knowledge, 2009.
5. Whitten, S, Abel, N and Cowell, S. *A scoping study of the market based opportunities available to eco-entrepreneurs in the rangelands. Report prepared for Bush Heritage Australia*. Canberra : CSIRO, 2008.
6. Abel, N, Farrier, D and Mooney, C. *A rangeland enmeshed: the legal and administrative framework of the Western Division of New South Wales. Report to the Western Lands Review*. s.l. : CSIRO, University of Wollongong, Department of Land and Water Conservation., 1999.
7. Lovelock, CE and Ellison, J. Vulnerability of mangroves and associated tidal wetlands of the GBR to climate change. [book auth.] J Johnson and P Marshall. *Climate Change and the Great Barrier Reef*. Townsville : Great Barrier Reef Marine Park Authority, 2007.
8. Oliver, D and Kookana, R. *Pesticide use in the Ord River Irrigation Area, Western Australia, and risk assessment of off-site impacts using Pesticide Impact Rating Index*. Canberra : CSIRO Land and Water, Technical Report 10/05., 2005.
9. Bishop, RC. Endangered Species and Uncertainty: The Economics of a Safe Minimum Standard. *American Journal of Agricultural Economics*. 1978, Vol. 60, 10.
10. Deville, A and Harding, R. *Applying the Precautionary Principle*. Sydney : Federation Press, 1997.
11. Elgar, Edward. Implementing the Precautionary Principle: Perspectives and Prospects. [book auth.] E Fisher, J Jones and von R Schomberg. *Implementing the Precautionary Principle: Perspectives and Prospects*. s.l. : Cheltenham, UK; Northampton, MA, US, 2006.
12. Stoneham, G, et al. The application of sustainability concepts to Australian agriculture: A review. *Australian Journal of Experimental Agriculture*. 2003, Vol. 43, 195.
13. Margules, C and Pressey, R. Systematic conservation planning. *Nature*. May, 2000, Vol. 405, pp. 243-253.
14. Brouwer, R. Environmental value transfer: State of the art and future prospects, . *Ecological Economics*. 2000, Vol. 32, 137.

15. Rolfe, JC and Bennett, JW. Choice Modelling and the Transfer of Environmental Values. [book auth.] Edward Elgar. Cheltenham, UK and Northampton, MA : s.n., 2005.
16. Bueren, M van and Bennett, JW. Towards the development of a transferable set of value estimates for environmental attributes . *Australian Journal of Agricultural and Resource Economics*. 2004, Vol. 48, 1.
17. Rolfe, JC and Windle, J. Valuing the protection of aboriginal cultural heritage sites. *The Economic Record*. 2003, Vol. 79, s85.
18. Imber, D, Stevenson, G and Wilks, I. *A Contingent Valuation Survey of the Kakadu Conservation Zone, Research Paper No 3, Resource Assessment Commission*. Canberra : Australian Government Publishing Service, 2001.
19. Rolfe, JC and Prayaga, P. Estimating values for recreational fishing at freshwater dams in Queensland. *Australian Journal of Agricultural and Resource Economics*. 2006, Vol. 51, 157.
20. Rolfe, JC and Windle, J. Valuing options for reserve water in the Fitzroy basin. . *Australian Journal of Agricultural and Resource Economics*. 2005, Vol. 49, 91.
21. —. Testing for differences in benefit transfer values between state and regional frameworks. *Australian Journal of Agricultural and Resource Economics*. 2008, Vol. 52, 149.
22. Spash, CL. Deliberative monetary valuation: issues in combining economic and political processes to value environmental change. *Ecological Economics*. 2007, 63, pp. 690-699 .
23. —. Deliberative monetary valuation and the evidence for a new theory of value. *Land Economics*. 2008, Vol. 84, 3, pp. 469-488 .