THE DALY REPORT

Part One. An assessment of the terrestrial conservation values of the Daly River Catchment and the threats posed by land clearing and agricultural development

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Executive Summary

The Daly is one of the great Australian tropical rivers. It drains a catchment of more than five million hectares. Springs, fed by wet season rains slowly release water back into the system throughout the year, creating flows all year round. This Dry season flow underpins the conservation value of the river and is of great significance for wildlife on land and in the river.

The potential further clearance of native vegetation for large scale agriculture in the Daly catchment is the single largest land clearing proposal currently being considered in Australia. The clearing proposal would directly affect wildlife and ecosystems across an area of approximately 100 000 hectares and would inevitably lead to the deaths of many millions of animals. There are also serious potential impacts on a range of ecological processes that would affect the integrity of the Daly River system as a whole.

Key Findings of this Report

Significant Values

The Daly catchment lies in the vast Australian tropical savannas region, which extends from Queensland to northern Western Australia. It is part of the most extensive area of *Eucalyptus* habitat in the world.

The Daly is one of northern Australia's most significant rivers, with a Dry season flow that is five times greater than any other river in the Northern Territory. The volume of the Dry season flow affords much more than aesthetic and economic significance. It provides significant habitat for an exceptional array of wildlife. Maintenance of the health of the whole landscape is vital to the wildlife of the riparian zone.

The Daly is an outstanding example of the relationships between groundwater and both terrestrial and aquatic flora and fauna. In the Daly, permanent or semi-permanent surface water becomes critical for the persistence of terrestrial animals such as the rainforest fruit-eating birds and bats, and freshwater wetland birds (such as Magpie Geese).

An area of continuous riparian rainforest (about 4000 hectares) along the lower reaches of the Daly River is the largest unbroken patch of rainforest in north-western Australia. The monsoon rainforests support specialist wildlife such as the Rainbow Pitta, Orange-footed Scrubfowl, Emerald Dove, Rose-crowned Fruit-dove and Pied Imperial-Pigeon.

Threatened species found in the catchment include the Gouldian Finch, Partridge Pigeon, Northern Quoll and Black-footed Tree-Rat.

Potential Threats

A total of 110 400 hectares between the Daly River and the Stuart Highway has been identified as suitable for clearing. Disturbance of native vegetation will affect the recharge of groundwater resources. It can be expected that replacement of savanna woodland with cleared land will increase overall catchment runoff, amplify flood events, and increase soil loss and therefore sedimentation. This is likely to affect vegetation dependent on groundwater discharge and associated wildlife.

If some rainforest patches are lost as a result of reduced groundwater flows, this could cause significant regional declines in fruit eating wildlife. The affected rainforest may be more water-stressed in the dry season and therefore more vulnerable to fire or less productive, affecting fruit-eating wildlife. Rainforest fruit-eaters at risk include the Rose-crowned Fruit-dove, Pied Imperial-Pigeon and Common Koel. This is a concern as the fruit eating bats and birds maintain plant diversity and health in all rainforests in the region, by dispersing seeds as they move between the patches. Impacts on these species could trigger a decline in the health of all rainforests in the region.

Wildlife losses from clearing in the Daly have already been recorded, with significantly lower species richness and density among plants, birds and reptiles at cleared sites. Patterns of decline after clearing throughout Australia suggest that species losses are likely to continue from the areas of the Daly that are extensively cleared.

When land is cleared some native species may benefit from the disturbance and become superabundant in the cleared habitats. This phenomenon has already been observed in recently cleared districts in the Stray Creek area. Generalist species such as Yellow-throated Miners, Pied Butcherbirds, Crested Pigeons and Galahs dominated the vegetation corridors of remnant woodland. Large uncleared areas of the same habitat less than a kilometre away supported a more diverse bird community.

Land clearing is already aiding the invasion of a number of serious environmental weeds into the Daly Region. The weeds of particular concern are Gamba Grass and the Mission grasses, which are noxious weeds introduced for pasture. The potential for further invasion of large areas by these weeds is high. The consequences of the spread of Gamba Grass and Mission grasses are severe, potentially transforming the north Australian landscape from biologically diverse open forest and woodland to alien grassland. Gamba grass in particular increases the intensity of savanna fires.

The Daly has large areas of edge habitat from which Gamba Grass can invade savanna woodland. Gamba Grass invasion of savanna was documented at a number of locations in the Daly catchment and it is evident that agricultural activity is hastening the spread of Gamba Grass into the Daly Basin.

Approximately 10-50 percent of wetlands would be affected by the agricultural development proposal, but the implications of these losses would reach far beyond these wetlands. Wetland loss in the Daly could have negative effects on Magpie Goose populations in other parts of the Top End including large protected areas such as Kakadu National Park.

Recommendations

1. Continue the moratorium on land clearing approvals for 3-5 years. This acknowledges the irreversibility and unpredictability of the potential threat to the natural integrity of the Daly system. The development proposals are the most significant in Australia with regard to the potential impact on biodiversity and as such deserve very careful scrutiny.

2. Extend the moratorium on land clearing approvals to the whole Daly catchment.

3. Further research is required to determine the extent to which water allocation planning would be affected by the loss of over 100 000 hectares of vegetation. Comprehensive assessment of the effects of proposed groundwater extraction on the health of rainforests in the Daly is also needed.

4. Assess the natural heritage significance of the Daly catchment in both a global and national context using criteria similar to those developed by Mackey *et al.* (2001). Any local proposals that affect the global and national values of the catchment should be assessed in this context.

5. Given that broad-scale land clearing is proposed on the Douglas, Tipperary, Jindare and Claravale pastoral stations, it is vital that each of these areas are surveyed by expert biologists. Current knowledge of the wildlife status of these areas is inadequate. For instance, Claravale station was not surveyed at all for the Daly Conservation Plan (2003), yet the endangered Gouldian Finch has been recorded just 8 kilometres from Claravale's eastern boundary in recent years.

6. Create a reserve network for the Daly only after fine scale vegetation mapping is completed, which will potentially detect and enable adequate reservation of hitherto undescribed vegetation communities.

7. Recognise the interconnectedness of ecological processes across the Study Area by maintaining ecological processes across tenures, supplementing a reserve system with measures to protect the natural integrity of the catchment on unreserved land.

8. Park proposals must be devised in conjunction with landowners, particularly traditional owners.

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1 Introduction

The Daly is one of the great northern Australian rivers, and with the greatest dry season flow in the Northern Territory. Much of this largely uncleared catchment rests on limestone aquifers that maintain this dry season flow, enabling the development of a diverse aquatic and terrestrial fauna and flora. The Daly's vegetation and groundwater resources are under considerable development pressure and its conservation values are poorly reserved. This report synthesises knowledge of the terrestrial conservation values of the Daly River and the potential effects of land clearing and associated water extraction on these values. Such an investigation is timely, as the proposed agricultural development (herein referred to as the "development proposal") in the Daly catchment is the largest single land-clearing venture being actively considered by government in Australia at this point in time. This development has the potential to affect the natural values of the Daly River and its catchment, and the cultural and economic uses of these.

1.1 The development proposal

The Daly Basin has the largest area of soils possibly suitable for cropping in the Northern Territory and there have been a number of agricultural ventures in the last century (Price *et al.* 2003). In this proposal (part of the Katherine-Daly Basin development), a total of 110 400 hectares between the Daly River and the Stuart Highway has been identified as suitable for clearing by the Department of Infrastructure, Planning and Environment. This includes 46 900 hectares on the Douglas Station, 34 000 hectares on Tipperary Station, 15 200 hectares on the Douglas Daly Farms and 14 300 hectares on the Stray Creek subdivision (DIPE submission to CRG). There are further proposals to subdivide Jindare and Claravale Stations and clear large areas of land on these (Price *et al.* 2003). Jindare and Claravale have approximately 77 000 hectares of potentially arable land.

1.2 This study

The Environment Centre of the Northern Territory, The Wilderness Society and the WWF Australia commissioned the study to investigate the potential threats of the development proposal to the terrestrial, aquatic and groundwater values of the Daly River catchment. This report presents findings of the terrestrial component of this study.

This assessment is a review of current existing published and unpublished knowledge of the conservation values of the Daly Basin, and the potential effects of broad scale land clearing on these values. The effects of land clearing on terrestrial biodiversity and ecosystem processes are investigated, including those that extend beyond the extent of the clearing itself ("ripple effects"). Flora and fauna that could be affected by the clearing are highlighted. Various approaches to landscape conservation and the possible consequences of applying these are investigated.

More specifically, the study analyses the threats of such development on the Daly River catchment by:

- Compiling and briefly reviewing available data on the fauna, flora and groundwater processes in the Daly River catchment
- Compiling and reviewing literature on the effects of land clearing
- Compiling unpublished local observations of the effects of land clearing
- Identifying elements of the flora and fauna that could be directly or indirectly affected by clearing.
- Compiling and reviewing literature on the effects of groundwater extraction on terrestrial vegetation and fauna
- Compiling and reviewing literature on the effects of weed invasion on terrestrial vegetation and fauna
- Assessing the nature of documented threats to biodiversity in the Northern Territory and identifying whether further clearing exacerbates these threats.

2 Overview of the Daly catchment

2.1 The Study Area

The Daly River catchment (the "Study Area") covers 5.26 million hectares. The Daly Basin Bioregion (2.08 million hectares) is central to the Daly catchment, which also extends into parts of the Darwin Coastal, Arnhem Plateau, Pine Creek, Victoria Bonaparte, Ord-Victoria Plain and Sturt Plateau Bioregions (Fig. 1). Most of the discussion in this report is focussed on the Daly Basin bioregion, on which the development proposal is centred, and references to the "Daly" refer to this bioregion.

The Study Area is part of the vast Australian tropical

Fig. 1. Planning Boundaries in the Daly Region

Source: Department of Infrastructure, Planning and Environment.
http://www.ipe.nt.gov.au/whatwedo/dalyregion/refgroup/focusarea.htm

savannas region, which extends from Queensland to northern Western Australia. Savanna woodland, characterised by Stringybark (*Eucalyptus tetrodonta*) and Woollybutt (*Eucalyptus miniata*) trees, dominates the landscape, varying from low open woodland to tall, well developed open forests.

The lower reaches of the Daly River itself are flanked by the riparian vegetation of Silver-leafed paperbarks (*Melaleuca argentea*) with Bamboo (*Bambusa arnhemica*) higher on the banks, behind which is a zone of monsoon rainforest. The floodplains associated with the lower river are clothed in open woodland. The river flats also support an extensive network of floodplain wetlands (about 200 000 hectares) and permanently moist depressions known as damplands (about 150 000 hectares) (Begg *et al.* 2001).

From information supplied to the Daly Community Reference Group by the Department of Infrastructure, Planning and Environment a total of 215 814 hectares has already been cleared of its native vegetation in the Daly Catchment, or about 4.6 percent – see Fig. 2. Therefore the Daly could be described as a relatively intact landscape (*sensu* McIntyre and Hobbs 1999).

However, there are a number of sub-catchments that have already been severely affected by clearing. Green Ant Creek sub-catchment, located on Tipperary Pastoral Lease, has had 59 percent of its native vegetation cleared. Douglas River and Stray Creek sub-catchments, both of which are targeted for further clearing, have already had 16 percent and 10 percent of their areas cleared respectively (from information supplied by DIPE to the Daly Community Reference Group). The clearing proposals will also affect the lower portion of the Fergusson River sub-catchment, Dead Horse Creek sub-catchment and nearby areas of the Daly sub-catchment. Further investigation of the sub-catchment level impacts of the clearing proposal is therefore urgently required.

2.2 Vegetation

2.2.1 Savanna woodlands

The savanna woodlands are part of the most extensive area of eucalypt habitat in the world, the tropical savanna woodlands of northern Australia (Woinarski *et al.* 2000b). This habitat type is by far the most extensive in the Daly catchment. While the savanna woodlands occur across northern Australia many wildlife are much less extensively distributed, such as the Gouldian Finch and Partridge Pigeon (see Section 2.5). Large numbers of birds congregate in *Eucalyptus tetrodonta-E. miniata* savanna woodlands in the dry season to exploit the abundant nectar (Woinarski *et al.* 2000b). A diversity of finches, parrots and pigeons forage on the abundant seeding grasses (Franklin 1999).

2.2.2 Monsoon rainforests

The monsoon rainforests of the Northern Territory exist as a network of approximately 15 000 patches surrounded by the extensive savanna woodlands, with most patches smaller than 5 hectares (median size: 3.6 hectares; Price *et al.* 1995). The plant diversity of these often tiny fragments of monsoon rainforest is maintained by fruit feeding birds and bats, which must move frequently between patches to ensure they obtain enough food. These movements carry seeds throughout the network of rainforest patches.

Riparian zones, which are often although not always monsoon rainforests in the Daly, are of major significance for wildlife in the Top End. They have a much higher bird species richness and abundance than the surrounding woodlands, and nectar-feeders contract to these relatively resource rich areas when nectar sources decline in the eucalypt woodlands with the onset of the late dry season (Woinarski *et al.* 2000). The interdependence of riparian and surrounding environments as components of a single landscape mosaic was noted by Woinarski *et al.* (2000), who suggested riparian bird assemblages required non-riparian habitats at particular times and vice-versa. They concluded that maintenance of the health of the landscape matrix in which these riparian systems exist was vital to the wildlife of the riparian zone.

2.3 Wildlife

There are ten threatened or significant species of terrestrial wildlife in the Daly Basin (Appendix 1). Wildlife of special interest as threatened and/or functionally important include the Gouldian Finch, Partridge Pigeon, Northern Quoll, Black-footed Tree-Rat, Rose-crowned Fruit-dove, Pied Imperial-Pigeon, Magpie Goose, Black Flying-fox and Little Red Flying-fox.

The savanna woodlands are the major habitat of wildlife such as the Gouldian Finch, Partridge Pigeon,

Fig. 2. Historical Land Clearing in the Daly River Catchment as at August 2003

Source: Department of Infrastructure, Planning and Environment

Hooded Parrot, Northern Quoll and Black-footed Tree-Rat. The Gouldian Finch, Partridge Pigeon are threatened seed-eating birds that have declined within the Northern Territory (Franklin 1999) and have nationally significant populations in the Study Area. The Gouldian Finch (nationally Endangered) has been found at a number of sites across the Daly catchment. One of Australia's most significant populations (the "Yinberrie Hills" population) (Dostine *et al.* 2001) is in the upper Daly catchment on the Edith and Fergusson Rivers. A continuing decline was reported for the Yinberrie Hills population (Garnett and Crowley 2000). The nationally Vulnerable Partridge Pigeon (eastern form) has contracted in range by more than 50 percent, and is now largely found on the Tiwi Islands, in Kakadu National Park and between Katherine and Darwin, including the Study Area (Garnett and Crowley 2000; J. Woinarski pers. comm.). It is most common where fire management allows for a small-scale mosaic of fire ages, enabling the birds to forage, nest and shelter (Garnett and Crowley 2000). The Northern Quoll, a species that has disappeared from large areas of the Australian continent (Braithwaite and Griffiths 1994) is still present. It is still found around houses and tourist parks in the Daly River/Wooliana district in the lower Daly River (J. Hilliard; V. Cowan pers. comm.).

The monsoon rainforests support specialist wildlife such as the Rainbow Pitta, Orange-footed Scrubfowl, Emerald Dove, Rose-crowned Fruit-dove and Pied Imperial-Pigeon. Black Flying-foxes may also be seasonally rainforest dependent as they were found to concentrate in rainforests in the wet season near Darwin (Palmer and Woinarski 1999), and may do so elsewhere in the Northern Territory. Functionally important fruit feeders include the Black and Little Red Flying-foxes, Rose-crowned Fruit-dove, Pied Imperial-Pigeon and Common Koel (see Section 4.1.1). The Northern Blossom Bat is probably also a major pollinator.

The floodplain wetlands are habitat for an array of wetland birds including large congregations of Magpie Geese. Other species include the Radjah Shelduck, Green Pygmy-goose and the Wandering and Plumed Whistling-ducks (waders and other waterbirds etc.).

2.4 The relationship between wildlife and groundwater

The Study Area is an outstanding example of the relationships between groundwater processes and both terrestrial and aquatic flora and fauna. The significant dry season flow (maintained largely by limestone aquifers, Begg *et al.* 2001) has enabled the persistence of a number of species that would otherwise be absent from the landscape. Many ecological processes in the Daly, like other monsoonal landscapes in northern Australia such as Cape York (Mackey *et al.* 2001), are dependent on the hydroecology (the relationship between biota and water). In the Daly, permanent or semi-permanent surface water becomes critical for the persistence of terrestrial animals such as the rainforest fruit feeders, and freshwater wetland birds (e.g. Magpie Goose). The relative importance of vegetation types dependent on groundwater often greatly exceeds their area, as they often represent perennially lush and productive environments in a much drier landscape (Hatton and Evans 1998).

3 Effects of land clearing

Land clearing is the single biggest threat to biodiversity in Australia (Williams *et al.* 2001; Morton *et al.* 2002). The effects of land clearing and losses of ecological function from the remnants that remain in extensively cleared landscapes have been detailed at length in the scientific literature. This work has identified major losses in wildlife (Cogger *et al.* 2003), hydrological changes including loss of springs (Fensham and Fairfax 2003) and land degradation (Glanznig 1995) as a result of large-scale clearing. The "Brigalow declaration", supported by 420 scientists, demonstrated a scientific consensus that broad-scale land clearing should cease in Queensland, and the first ever position statement of the Ecological Society of Australia in 1995 also called for controls on clearing. The Wentworth Group of concerned scientists, which includes eminent scientists across a range of disciplines, called for an end to broad scale land clearing of native vegetation in Australia (Wentworth Group 2002).

3.1 Direct effects

This section describes the direct effect of clearing on wildlife populations and effects on remnants within extensively cleared landscapes.

3.1.1 Direct loss of biota

When land is cleared, the great majority of the wildlife is killed. Some are directly killed by the action of the bulldozers, especially those sheltering in hollows or under bark, as many reptiles and some birds and mammals will do during the day. Many more die shortly afterwards as their food and shelter has been lost. Adjacent bushland rarely acts as a refuge as it is already occupied by resident animals, which are using the food and shelter available (Cogger *et al.* 2003). Cogger *et al.* (2003) estimated that the clearing of 446 000 hectares a year in Queensland led to the loss of approximately 2.1 million mammals, 8.5 million birds and 89 million reptiles. If animal densities are similar in the Study Area, the development proposal would result in the death of more than 20 million vertebrate animals and permanent loss of their habitat. Price *et al.* (2003) have already recorded wildlife loss from clearing in the Study Area; with significantly lower species richness and density among plants, birds and reptiles at cleared sites.

3.1.2 Invasive fauna, potentially causing further loss of biota

When land is cleared some native species may benefit from the disturbance and become superabundant in the cleared habitats. Such inflated abundances may be just as great a symptom of ecosystem dysfunction as declines. In some instances, native species with inflated abundances may cause further decline in other native species. This form of bird community imbalance and subsequent loss of diversity has occurred in many disturbed landscapes in Australia (Loyn 1987; Grey *et al.* 1998; Piper and Catterall 2003).

Clearing creates thousands of hectares of high quality habitat for these "increaser" species, which generally thrive at the interface of the cleared land and bushland remnants, including very small remnants. Some increasers appear to be benign, such as the Australian Bustard and Crested Pigeon, but others, notably aggressive large honeyeaters (e.g. Yellow-throated Miner) and nest predators (e.g. Pied Butcherbird, Torresian Crow) that kill or exclude smaller "bush bird" species in the adjacent remnant vegetation. The outcome is a bird community that scarcely resembles the original woodland community in either the vegetation corridors or the remnant vegetation within the agricultural landscape. This process can render smaller retained remnants and habitat corridors useless for the smaller bush birds.

This phenomenon has already been observed in recently cleared districts in the Stray Creek area, where large areas were cleared in 2001-02. Generalist species such as Yellow-throated Miners, Pied Butcherbirds, Crested Pigeons and Galahs were found to dominate the vegetation corridors of remnant *Eucalyptus tetradonta-E. miniata* woodland (B.Traill pers comm.; SJK pers. obs.). Large uncleared areas of the same habitat less than a kilometre away supported a more diverse bird community, which included small bushland birds such as the Banded Honeyeater and Restless Flycatcher (SJK pers. obs.).

3.1.3 Regional extinctions

Species loss from remnants may continue for decades after the clearing occurs in a region. Local extinctions occur because small populations are vulnerable to inbreeding, bushfire and drought. These local extinctions combine to result in regional extinctions (Cogger *et al.* 2003). This pattern has been confirmed in a range of studies in southern Australia (Robinson and Traill 1996; Traill *et al.* 1996; Traill and Duncan 2000; Possingham and Field 2001 and Kennedy 2003) that describe local extinctions of woodland birds many decades after clearing.

Studies of the effects of land clearing have also been conducted in the north. Rankmore and Price (2004) studied fragmentation effects on fauna at Tipperary station in the Daly and the Humpty Doo area east of Darwin. They found that the Northern Quoll and Black-footed Tree-Rat were already of particular concern. A total of 28 species were found to respond negatively to fragmentation, i.e. they have disappeared from some remnants. The Northern Quoll was absent from patches in landscapes with less than 65 percent woodland within 4 kilometres of the remnant. However, as Rankmore and Price (2004) acknowledge, their results only capture the early ecological consequences. Local extinctions in their study area are unlikely to be complete, as all remnants have been isolated only in the last 30 years including many in the last 10 years. It is therefore likely that will continue local extinctions for several more decades at least. Based on these patterns the Daly Basin has lost species from recently cleared areas but will lose many more in the coming decades.

3.2 Ripple effects

Of particular concern in the Study Area are the "ripple effects" beyond the boundaries of the clearing itself (Section 3.2). The area degraded by clearing usually exceeds the area of land actually cleared but the risk of substantial ripple effects appears to be unusually high in the Daly Basin. This is because ecosystem processes rely on a little known hydroecology and the potential for invasion by "ecosystem transformer" weeds is substantial (Section 3.2.2). Furthermore, the monsoonal climate increases the risk of single heavy rainfall events causing significant damage to the Daly River downstream of cleared areas. If observations of highly accelerated rates of siltation in the lower Daly River by traditional owners and local fishermen (G. Higgins, B. Lindsay, A. Myoung pers. comm. September 2004) are the result of land clearing, then the clearing of 4.6 percent of the Daly catchment has already impacted the Daly River downstream of the main agricultural areas, including river reaches tens of kilometres from any clearing.

A letter from the Daly River Community Development Association (DRCDA) to the Northern Territory Chief Minister (dated 13 August 2004) gives further weight to this view. It cites a talk given by Professor Eric Wolanski of the Australian Institute of Marine Science and David Williams, Manager Water Resources Assessment at the Department of Infrastructure, Planning and Environment, at Wooliana Community Hall on 4 August. According to the DRCDA, the residents were told that the Daly is in danger from bank collapse resulting in a wider shallower river, increased siltation, increased levels of sand travelling downriver, weed proliferation and a smaller tidal bore. Wolanski and Williams did not indicate how many of these changes could be directly attributed to land clearing, but this question clearly requires further investigation.

3.2.1 Invasive flora

Invasive weeds are often a problem within remnants in cleared landscapes. In addition, the tropical savannas several weeds have the potential to invade beyond these landscapes into large areas of otherwise little disturbed habitat.

The weeds of concern in the savanna woodlands of the Daly are Gamba Grass (*Andropogon gayanus*) (a noxious weed introduced for pasture), and the Mission Grasses *Pennisetum polystachion* and *P. pedicellatum*. The potential consequences of the spread of these tall grasses are serious. Kean and

Price (2003) state that the "*The north Australian landscape could be altered from biologically diverse open forest and woodland to alien grassland with little native flora and fauna*".

Rossiter *et al.* (2003) describe Gamba Grass as an "*ecosystem transformer*", a type of weed that can covert savanna into grassland across large areas. Gamba Grass has the ability to modify fire regimes, introducing a "grass-fire cycle" wherever it invades (Rossiter *et al.* 2003). The grass-fire cycle is a process where an alien grass invades new habitat and increases the overall fine fuel level, increasing fire frequency and/or intensity. The next fire will reduce tree and shrub cover, facilitating further grass invasion, and increasing the likelihood of an even more intense fire, perpetuating the cycle. Gamba Grass appears to represent a particularly severe example of the grass-fire cycle in Australia, as Rossiter *et al.* (2003) reports that savanna invaded by Gamba Grass has seven times the fuel load of uninvaded areas and caused fires that averaged eight times the intensity of natural savannas. The scorch height of the fires is significantly higher, a factor that has the potential to greatly alter species composition. Kean and Price (2003) suggest the effects on fauna of this process are likely to be "*profound*".

Mission Grasses and Gamba Grass are spreading rapidly in savanna woodland in the Litchfield Shire immediately to the north-east of the Daly. This is a habitat similar (albeit with a higher rainfall) to what is found across much of the Daly. Mission grass is already considered to be so widespread that only local control can be considered (Kean and Price 2003). Mission Grasses could potentially invade half the Litchfield Shire (400 000 hectares) within 35 years, and Gamba Grass could invade most of the shire within 80 years (Kean and Price 2003). This would equate to a rate of spread in the shire of around 3-6000 hectares/year (Table 1).

Kean and Price (2003) considered that all habitat within one kilometre of a road or track is highly vulnerable to invasion by Mission Grass within 35 years and Gamba Grass in approximately twice this time in the Litchfield Shire. If this assumption is made for the Daly, and cleared areas are considered to be sufficiently disturbed to pose the same threat as a road, then a large area of the Daly is at risk. The actual area at risk depends on the number and size of the cleared paddocks. If the 110 400 hectares identified for clearing was split into ten clearings of around 11 000 hectares each, then 41 720 hectares of land will be within 1 kilometre of a clearing (assuming that each cleared area is more than one kilometre apart). However if the area is split into 50 clearings of around 2000 hectares each, then the area at risk (i.e. within 1 km of clearing) is 93 400 hectares (assuming that each cleared area is more than one kilometre apart). About 45 000 hectares in the Litchfield Shire has been cleared compared to nearly 200 000 hectares in the Daly (Hosking 2002).

Therefore the Daly has larger areas of edge habitat from which Gamba Grass can invade savanna woodland. The spread would be uneven, as the perception of the utility of Gamba Grass varies greatly among landholders, with some planting it for pasture and others wanting to eradicate it. Cleared areas sown to exotic pasture for more intensive grazing will have the greatest ripple effects, more so than cleared areas retaining native pastures or sown to intensive horticulture. However, it is estimated that more than 1000 holdings in the Litchfield Shire have the grass despite their owners not planting it (O. Price pers. comm.), so it is evident the grass can eventually spread well beyond plantings.

There appears to be no feasible option for broad scale eradication or even containment of these virulent weeds once they are established. Kean and Price (2003) consider that Gamba Grass is likely to enter all available habitats in the Litchfield Shire, i.e. savanna within 1 kilometre of a disturbance such as road or cleared paddock within a few decades. The commencement of broad-scale land clearing will introduce these weeds to new areas, which will necessitate expensive control and restoration work.

Gamba Grass invasion of savanna was recently observed at a number of locations in the Daly catchment, including savanna woodlands adjacent to the northern part of Tipperary station, on Oolloo Road north of the Douglas River, near Wooliana Primary School, and a roadside near woodland at Stray Creek (SJK pers. obs.). A ten-kilometre stretch of woodland along the Daly River Road through the northern part of the Tipperary station is infested with the grass, with the infestation varying from single scattered clumps to denser stands (SJK pers. obs.). The Stray Creek, Tipperary and Douglas invasions were evidently associated with agricultural activity in those areas. The Wooliana invasion is less obviously related to pasture planting but is said to have been brought to the area by a local landholder (V. Cowan pers. comm.). These infestations were not as severe as those described in the Litchfield Shire, but it was evident that agricultural activity is hastening the spread of Gamba Grass into the Daly Basin.

Table 1. Possible rates of spread of Mission Grasses and Gamba Grasses in the Litchfield Shire. (adapted from Kean and Price 2003).

Grass type	Area predicted to be occupied	Time (years)	Rate of spread
Mission Grasses	Approx 200 000 ha	35	5714 ha/year
Gamba Grass	Approx 300 000 ha	80	3750 ha/year

Introducing weeds that are a "*serious threat to the ecological integrity of northern Australia*" (Kean and Price 2003) and for which there is currently no prospect of control beyond the local level is obviously inadvisable. Gamba Grass is still commercially available as a pasture grass (e.g. http://www.southedgeseeds.com.au/10.htm) and is still planted in the area (O. Price pers. comm.).

3.2.2. Altered hydrology

Reduced groundwater recharge will affect vegetation dependent on groundwater discharge and associated wildlife, a key ecological feature of the Daly Basin. Loss of vegetation cover affects the recharge of groundwater resources (Mackey *et al.* 2001). We can expect that replacement of savanna woodland with cleared land will increase overall catchment runoff, amplify flood events, and increase soil loss and therefore sedimentation (Erskine *et al.* 2003).

Several vegetation types need groundwater. Hatton and Evans (1998) considered that there was evidence that monsoon rainforests, paperbark swamps and tropical woodlands are dependent on groundwater in the dry season. Groundwater is clearly critical for spring-fed rainforests (Liddle and Scott 2003) (section 4.1.1). Groundwater is also important for wetland hydrology in the Daly, with most wetlands in groundwater discharge areas Begg *et al.* 2001).

Erskine *et al.* (2003) responded to these potential threats by recommending environmental water allocations to maintain the ecosystem values of the Daly. The authors caution that these recommendations will need to be modified if further clearing occurs. Further study would be required to determine the extent to which the recommendations of Erskine *et al.* (2003) are affected by the loss of approximately 100 000 hectares of vegetation. All that can be said with certainty is that it will further reduce recharge (increase wet season runoff) and therefore reduce the reliability of dry season spring flows (Erskine *et al.* 2003).

Regions where there has been extensive groundwater extraction and land clearing have already experienced significant losses of groundwater dependent habitats. For example, Fensham and Fairfax (2003) studied the springs of the Queensland section of the Great Artesian Basin (except for Cape York) and found that only 36% of the 300 original spring groups in discharge areas (i.e. down-gradient of the recharge areas) still had active springs.

4 Species and ecosystems at risk from land clearing and water extraction

4.1 Rainforests and dependent wildlife

There are number of areas of spring-fed rainforests in the northern part of the Daly Basin, some of which are on the Daly River itself. These may be affected by groundwater extraction reducing the quality and quantity of groundwater recharge. This in turn could affect the health of all the rainforests in the region, because of the effect on fruit feeding wildlife (Section 4.1.1)

Detailed work in similar habitat in the Darwin area has identified significant risks to spring-fed rainforest from groundwater extraction. The Darwin spring-fed rainforests are similar to those in the Daly Basin, in that they exist as small patches surrounded by savanna woodland. The impact of groundwater extraction on rainforest is sufficiently serious for Liddle and Scott (2003) to suggest that alternative water supplies to parts of Darwin may be needed to reduce the risk of destroying habitat of the Endangered Darwin Palm, a species restricted to this habitat (*Ptychosperma bleeseri*). Liddle and Scott (2003) considered it "*probable*" that altered hydrology has resulted in the drying of an important remnant rainforest for the Darwin Palm, increasing vulnerability to fire. A fire subsequently occurred in the early 1990s, burning "right through" the remnant and destroying a significant number of adult Darwin Palms. A relatively subtle "drying out" of spring-fed rainforests is more likely in the short-term than an immediate and visible devastation. The affected rainforest may be more water-stressed in the dry season and therefore increasing fire risk and reducing productivity, affecting fruit eating wildlife.

Adequate assessment of the effects of groundwater extraction on the health of spring-fed rainforest will be expensive. Study of the hydrology and potential effects of water extraction on the Black Jungle reserve and Whitewood Road rainforests was considered sufficiently important for (Liddle and Scott 2003) to recommend that $545 000 or 60% of the total budget for the 2004-2008 Recovery Plan for the Darwin Palm be allocated to this issue. While this example is related to an Endangered species, the health of the Darwin Palm populations is a reflection of the health of the rainforests in that area. If the aim is to maintain the health of spring-fed rainforest, assessment of the effect of proposed groundwater extraction would need to be just as comprehensive in the Daly Basin. This will ascertain whether aquifers are interconnected or discrete and therefore if the issue will be localised or more widespread.

4.1.1 Rainforest fruit feeders

The rainforests of the Northern Territory are maintained by fruit eating bats and birds. These species (e.g. Rose-crowned Fruit-dove, Pied Imperial-Pigeon, Common Koel, Black Flying-fox) consume the fruit of trees and shrubs, dispersing the seeds as they move between the isolated patches. This maintains plant diversity and health of all the rainforests in the region. If some rainforest patches are lost as a result of groundwater drawdown, this could cause significant regional declines in fruit eating wildlife. This could trigger a decline in the health of all rainforests in the region. The monsoon rainforests are interconnected. Fruit feeding birds and bats need a network of rainforest patches in a region to survive. This network provides a year-round supply of food as a range of different plants and rainforest types fruit throughout the year. Studies of rainforest fruiting times in the Darwin area have found that fruiting in the wet monsoon rainforests peaks earlier than in the dry rainforests (Bach 2002). In the Daly, the riparian rainforests are classified as dry rainforest and the spring-fed rainforests as wet rainforest (Russell-Smith 1991). If a similar pattern exists in the Daly Basin, then the wet spring-fed rainforests, although small in area, are likely to play a role in maintaining a large number of the region's fruit eating wildlife at certain times of the year.

Studies east of Darwin in an area similar to the Daly Basin (i.e. small patches of rainforest surrounded by savanna woodland), showed that the Rose-crowned Fruit-dove, Pied Imperial-Pigeon and Common Koel and about 30 associated plant species would decline with even minor decreases in regional rainforest cover within a 50 kilometre radius (Price *et al.* 1999). Major declines would be expected from reserves even as large as Litchfield National Park (146 100 ha) if the rainforest patches around it were lost (Price *et al.* 1999).

4.2 Wetlands and dependent wildlife

Wetlands and dependent fauna will be directly affected by land clearing, and also by groundwater extraction. Approximately 10-50 percent of wetlands would be affected by the development proposal (Begg *et al.* 2001). This would have implications for wildlife that rely on a network of wetlands (e.g. Magpie Goose). If these mobile wildlife have a functional role in maintaining ecological processes (e.g. vegetation structure) in these wetlands, then their decline would also affect the health of other wetlands in the region not directly affected by groundwater loss.

4.2.1 Magpie Goose

The Magpie Goose is one of the iconic wildlife species of northern Australia. The large flocks that congregate on the wetlands are one of the great natural spectacles of Australia's north. The species breeds in the wet season on the floodplain wetlands, with approximately 95% of the Top End population (including the Daly) on eight major coastal rivers between Cobourg Peninsula and the Western Australian border. The spatial distribution of the wet season breeding population fluctuates greatly between years in response to variability in rainfall events, with surveys demonstrating that population concentrations shift between the major river systems (Whitehead *et al.* 1992) (Fig. 3). Price *et al.* (2003) describe the movements of the Magpie Geese as dictated by water levels, with bulbs of the sedge (*Elaeocharis sp.*) only accessible to geese when the ground is wet enough to extract them but the water is not so deep that the geese cannot reach them.

There is no guarantee of adequate reservation of major population concentrations in all years despite the large areas of wetlands in the reserve estate. Wetland loss in the Daly will have negative effects on Magpie Goose populations in other parts of the Top End including large protected areas such as Kakadu National Park. Woinarski *et al.* (1992) commented that similar patterns were "probable" among some other wetland birds, which have not been as well studied. These may include other freshwater herbivores such as the Radjah Shelduck and the Whistling-Ducks.

Fig. 3. Variation in Magpie Goose populations 1984-1991. (source Whitehead *et al.* 1992)

4.3 Seed-eating birds of savanna woodlands

Savanna woodlands in general are at risk from invasion by weeds introduced by clearing (Section 3.2.1), but seed-eating birds, already in major decline as a result of pastoralism (Franklin 1999), are of particular concern. Gamba Grass produces seeds that are used by native finches (D. Franklin pers. comm.), but the ability of Gamba Grass to outcompete native grasses will result in near monocultures where no seeds are available for a long period of each year. This upsets the seasonal mosaic of seed supplies that would maintain a diverse array of seed-eating birds. The resilience of the seed-eating birds to disturbance varies, but species known to have declined in response to habitat degradation and loss of natural food mosaics include the Gouldian Finch, Partridge Pigeon, Star Finch and Pictorella Mannikin (Garnett and Crowley 2000).

5 Conservation options in Northern Australia

A range of approaches to conservation could be applied in northern Australia. The Northern Territory government has produced a Conservation Plan (Price *et al.* 2003) based on the CAR (Comprehensive, Adequate and Representative) approach to reserve design (Section 5.2). The plan is analysed and critiqued here, and alternative approaches are considered.

5.1 CAR system

A significant driver of conservation planning in Australia has been the CAR (Comprehensive, Adequate and Representative) approach to reserve design (JANIS 1997; Kirkpatrick 1998). Comprehensiveness means that all species and ecosystems are included, with vegetation communities designated as the "units" used to represent ecosystems. Adequacy means reserves are large enough to support viable populations. Representativeness means that the geographical variation of a species or ecosystem is adequately protected, that the sample areas should reasonably reflect the diversity *within* the communities. The most thorough attempt to apply a CAR model has been in the Regional Forest Agreement processes for forested landscapes in southern and eastern Australia.

The "Comprehensiveness" criterion is the easiest to measure. The ecosystem units are mapped and percentage targets set for each type. "Adequacy" and "Representativeness" are more difficult to measure, and Nix and Mackey (2001) note that no tangible targets were set for these criteria in Regional Forest Agreement process, resulting in an *ad hoc* application (Nix and Mackey 2001). The "nationally agreed" reserve criteria based on CAR weakened the original concept, and were the result of a political compromise (Kirkpatrick 1998). Figures of 10 or 15% protection of each ecosystem type have no scientific basis (Nix and Mackey 2001).

CAR has arguably advanced the incorporation of conservation biology into decision-making. A significant improvement on previous approaches has been the explicit aim to represent all ecosystem types, requiring addition of the "productive flat" lands to the reserve system, rather than only unproductive areas. However its application has generally overlooked requirements for long-term maintenance of ecological processes. Biodiversity conservation should aim for conservation of species and communities *and* the maintenance of ecological processes needed to support them. However, the narrow application of CAR to date has focussed on species and known biological associations (Nix and Mackey 2001). The reservation of a sample of a particular community will not always protect the ecological processes maintaining the integrity of that community. CAR systems as typically applied in Australian landscapes may be comprehensive but fail to address adequacy. Generally, an arbitrary percentage of land is reserved, without consideration of what is needed to protect ecological processes. In the Daly one could successfully achieve conservation of every ecosystem in the Daly (i.e. fully comprehensive) but fail to protect the ecological processes that maintain each ecosystem.

A key example is the spring-fed rainforests. Protection of 100 percent of spring-fed rainforests from direct disturbance will not address two major potential threats to its persistence, namely inappropriate fire regimes and alterations to the quality and quantity of groundwater discharge. The Black Jungle Conservation Reserve east of Darwin is a fully protected spring-fed rainforest that is threatened by groundwater extraction and subsequently ecologically inappropriate fire regimes (Liddle and Scott 2003) (see Section 4.1.1). Preservation of the ecological integrity of such communities requires action well beyond their boundaries.

In the Daly there is a combination of serious and irreversible potential consequences from current development proposals, a highly interconnected and little understood relationship between terrestrial wildlife and groundwater, a poor and patchy knowledge of wildlife and flora and an absence of fine-scale vegetation mapping from which to design reserves.

A reserve system that protects an arbitrary target percentage of the Daly catchment without legislative measures to protect ecological processes would be of concern for several reasons.

- There are major development proposals for the Study Area that previous experience in Australia suggests will greatly impact ecological processes. These proposals would directly impact about 100 000 hectares of vegetation, and will have implications for ecological processes over a much greater area than this.

- The combination of a monsoonal climate, geology and the function of groundwater dependent vegetation make hydroecology unusually important in the Study Area. A number of wildlife and flora depend on the quality and quantity of groundwater discharge. The condition of the native vegetation cover across the entire catchment is a key factor in maintaining the integrity of these processes by enabling wet season recharge rather than runoff.

- The Study Area is vulnerable to a weed threat considered capable of exceptional ecological damage and for which there is currently no feasible control solution. Clearing exacerbates this weed threat.

- Dispersal and dramatic population fluctuations in response to a variable climate are pervasive features of much of the Northern Territory's monsoonal fauna. These fluctuations prevent the adequate conservation of these fauna in a conventional reserve system.

- The Study Area as a whole is part of a globally significant landscape, the tropical savannas of Australia. Intact tropical landscapes are a global rarity.

5.2 Critique of the Daly Conservation Plan

The Northern Territory Government's plan to pursue agricultural development in the Daly Basin includes studies of resource capability and natural values with a stated aim of realising agricultural potential in a sustainable manner. The Draft Conservation Plan for the Daly Basin Bioregion (Price *et al.* 2003) is a key document with regard to flora and fauna inventory and reserve design. The Conservation Plan aims to ensure that species, ecosystems and ecological processes in the Daly Basin are adequately conserved. Particular goals include that no vertebrate, macro-invertebrate or vascular plant becomes extinct in the bioregion, that ecological processes continue to function (including water and nutrient cycling) and that the ecological character of ecosystems (e.g. species balance) is retained. The Conservation Plan includes an overview of the flora and fauna, plans for development, and importantly recommendations for an expanded reserve system in the Daly Basin bioregion, and measures to protect significant habitat outside reserves.

Modelling software was used to identify reserve options. The reserve system aimed to protect 15% of each broad land unit and 15% of the modelled distribution of 12 plant and three animal species for which there were sufficient data to extrapolate distribution. National Parks are proposed on the Fish River (300 000 hectares), the Upper Douglas catchment (120 000 hectares), on limestone country south of the Katherine (area to be determined) and on the upper reaches of the Flora River and Bradshaw Creek (120 000 hectares).

5.2.1 Survey effort and coverage

The Northern Territory Wildlife Atlas has approximately one wildlife record per 190 hectares (about 27 500 records) in the Daly catchment. By contrast, the Lower North-east Regional Forest Agreement region of New South Wales, which is similar in size (about 5.8 million hectares) to the Daly Basin, has approximately one wildlife record per 12 hectares (about 475 000 records) (RFA 2000). The Daly is a very large area with few roads and access points. However the natural integrity and threats faced in this area mean that knowledge gaps of this size in areas at risk must be surveyed. These surveys need to occur throughout the year, as one-off surveys in an environment as variable as that of the Northern Territory are unlikely to give an accurate representation of the value of any site to wildlife. Woinarski and Tidemann (1991) comment that one-off surveys would have created an unrepresentative and incomplete account of the birds in their study in deciduous eucalypt woodland at Yinberrie Hills in the upper part of the Edith River. This is probably also true for the Daly Basin. Woinarski (2004) considered the current knowledge base in the Daly to be about an order of magnitude too small to be an adequate for the monitoring of population changes for most terrestrial vertebrate species.

In particular, given that broad-scale land clearing is proposed on the Douglas, Tipperary, Jindare and Claravale stations (Fig. 4), it is critical that each of these areas are adequately surveyed in both the wet and dry season by expert biologists. Claravale station, which at 61 300 hectares is nearly half the size of Litchfield NP, was not surveyed at all for the Conservation Plan. Only 39 species of fauna have been recorded on Claravale station (NT Wildlife Atlas and Birds Australia Atlas data). The endangered Gouldian Finch has been recorded just 8 kilometres from Claravale's eastern boundary in recent years (Birds Australia Atlas records). These sightings are on the Stuart Highway where it crosses the Fergusson River (Fig. 5).

Only one survey was conducted on Jindare station (120 500 hectares) and was not in an area suitable for clearing. Jindare as a whole has a relatively large list of 151 species. However the part of the station south of Umbrawarra Gorge (an area of about 75 000 hectares) is little known with only seven wildlife atlas sites and 74 species recorded (NT Wildlife Atlas and Birds Australia Atlas). This is the section where most of the clearing would take place if Jindare was to be subdivided. Habitats on similar landforms have been surveyed in other areas, but there is still potential for flora and fauna not found elsewhere to be present here, as a result of geographical variation or differences in management (especially fire management).

There are also significant gaps in the Stray Creek area, with no records from an area of about 40 000 hectares centred on Fleming and Cadell Roads, at the centre of recent clearing activity in this area. It is evident that no pre-clearing surveys were undertaken to assess whether threatened wildlife were present in this area, or if they were, they were not reported to the NT Wildlife Atlas.

5.2.2 *Type of wildlife surveyed*

There were no terrestrial invertebrate surveys. While it is admittedly impossible to obtain a comprehensive inventory, invertebrates are worthy of investigation as they display a level of specialisation and short-range endemism not found among the vertebrates. Many invertebrates are as important for ecosystem function as vertebrates (Woinarski 2004). The spring environments, limestone outcrops and cave systems may support unique and specialised invertebrate fauna, as they do in other parts of Australia that have been intensively studied (e.g. Solem and McKenzie 1991; Stanisic 1996).

5.2.3 *Reserve design*

Land units were used as ecosystem units instead of vegetation types, which are only mapped at a coarse scale in the Daly. Land units are defined by soil, landform and vegetation and were mapped in a number of studies investigating the natural resources of the region. A total of 56 land units were defined in the Daly Basin. The Conservation Plan addresses comprehensiveness (reserving a proportion of each land unit) but the actual percent protection of each land unit, a crucial statistic, is not mentioned. For example, it is noted that the Fish River proposal protects examples of 45 of the 56 land units in the Daly, but without knowing how much of each unit is protected we do not know how effective this reserve will be. The proportion of ecosystems in the reserve estate (but not the proportion of each ecosystem) has also been reported as a measure of success in other major recent assessments (e.g. Sattler and Williams 1999), but it is only part of the story. More than 60% of the ecosystems in the Brigalow Belt and New England Tableland bioregions of Queensland are *represented* in reserves, but 83% of ecosystems have a very low proportion (less than 2%) of the pre-

Fig. 4. Potential agricultural areas, previous land clearing, and wildlife survey data on selected pastoral leases and freehold blocks in the Daly Basin Bioregion.

Source of data: Department of Infrastructure, Planning and Environment.

Notes on the map:

1. Locations of previously cleared areas are only shown as an approximation as the GIS data was not made available by DIPE.
2. Bird Atlas and Wildlife Atlas data includes threatened species records shown in Fig. 5.
3. As explained in the accompanying text, few wildlife surveys have been carried out on these selected pastoral leases and freehold blocks.

Fig. 5. Distribution of three threatened species in part of the Daly Basin Bioregion

Source of data: Department of Infrastructure, Planning and Environment

clearing area protected (Keto *et al.* in press.). Both statistics should be reported.

The only vegetation mapping that covers the Daly region comprehensively is at 1:1 000 000 scale, far coarser what is nationally regarded as an adequate standard for land-use planning (Woinarski 2004). Price *et al.* (2003) note that finer-scale vegetation mapping (1: 250 000) would be useful in reviewing the Conservation Plan. Given the potential effects of the clearing proposal, it is reasonable to suggest such mapping is actually essential to consider reserve options. Without it, distinctive components of the environment could be unreserved and then eliminated by clearing (Woinarski 2004) or its ripple effects. This finer-scale vegetation mapping could then become the ecosystem unit on which the "Comprehensiveness" criterion is based, rather than the Land Unit as in the Conservation Plan. The use of vegetation types as ecosystem surrogates may be expected to capture a greater deal of geographical variation than land units.

5.2.4 *Assumptions made in the Conservation Plan*

"Fortunately there is no set of fauna or flora species closely associated with good farming soils in the Daly Basin… it will be largely possible to avoid the best agricultural land".

This makes the assumption that the flora and fauna are well known. We would need to know more about flora and fauna to make such an assumption. Experience in a range of landscapes indicates that some fauna and flora are likely to be associated with particular soil types. Many of the highly arable areas are poorly surveyed such as Stray Creek and Claravale station (see Section 5.2.1).

"*The greatest conservation challenge is to accommodate increased agricultural development with the least impact*."

This depends on the public's willingness to accept increased agricultural development if it understands that there will be major impacts on the environment despite conservation planning. This assumption suggests broadscale land clearing is the only path of increased agricultural development.

"*It is widely recognised that reserve systems should ideally constitute around ten percent of any jurisdiction and each major environment*."

The ten percent figure has no scientific basis. It was agreed on by the IUCN (1994), but is widely known to be a "politically acceptable compromise" (Soule and Sanjayan 1998).

"*It may be that any loss to the landowners occasioned by the establishment of new parks can be offset by the benefits to be derived from new more intensive agricultural opportunities*"

This depends greatly on the nature of the intensive agricultural opportunities. The proposal appears to be driven by a proposal to reduce the area under pastoral management and increase the area for conservation, and that the clearing of some areas will still result in a better overall outcome as pastoralism (which has reduced many species) will be less dominant in the landscape. The efficacy of such an approach depends entirely on the nature of each "offset" (such as what "intensive agricultural opportunities" may entail).

5.3 Other conservation approaches for Northern Australia

In the last decade there has been a broad realisation in the conservation biology discipline that landscape scale conservation is needed to protect natural values in the long term. As discussed in Section 5.1 there is now increased knowledge on the importance of protecting not only individual species but also the ecological processes and large scale ecological connections that maintain those species (e.g. Mackey *et al*. 2001; Soule *et al.* in press.)

These processes include hydro-ecology, fire regimes, and the long distance movements of species, including pollinators and seed dispersers.

However there has been relatively little focus on developing conservation models appropriate for the intact landscapes of northern Australia.

Woinarski *et al.* (1992) presented a number of case studies to demonstrate that in the Northern Territory there are "*…substantial shortcomings in the conventional reserve network consisting of discrete National Parks, isolated by land used primarily for uses other than conservation*."

The authors considered four options for reserve design for the NT and their potential problems:

a) *Status quo, with improvements to ensure all vegetation types are included in the reserve network.* **Problems:** Lack of conservation influence over land between isolated reserves, denying flexibility in management options for animals that respond to seasonally changing conditions, especially when movements are within a major habitat type that is only partly protected.

b) *Seek inclusion into the reserved land system of the whole of the known habitat of important species (e.g. all wetlands for Magpie Goose).* **Problems:** What species should be chosen to base the system on? Difficulty in delineating critical habitat for some species. Economic obstacles.

c) *Develop very large reserves that span extensive slices of the environmental gradient.* **Problems:** Magpie Goose movements demonstrate shortcomings of this option, with data demonstrating that large numbers congregate outside Kakadu National Park (the reserve that best represents this option) in some years in response to rainfall fluctuations.

d) *Supplement the representative reserve network with measures that protect wildlife habitat on large areas of unreserved land.* **Problems:** The only obstacle identified was the low appreciation of the conservation role of unreserved land as a result of its great extent.

Woinarski *et al.* (1992) concluded their paper by acknowledging the political obstacles and acknowledging that a "*view of land still widely held by non-aboriginal residents of the NT is that it is useless and unproductive unless substantially modified. How else is it possible to explain a determination to clear large areas of savanna woodland, when available evidence suggests that initial and ongoing costs of mechanical and chemical clearing of woody vegetation often exceeds returns from increased pastoral production*?". The problem identified by Woinarski *et al.* (1992) in option d) of low appreciation of large tracts of vegetation because they are so extensive has arguably changed to some degree, in scientific circles at least.

A key document in assessing the ecosystem services and values of extensive areas of native vegetation, especially in monsoonal landscapes, is the overview of the natural heritage significance of the Cape York Peninsula by Mackey *et al.* (2001). The report introduced perspectives on the national and global value of the Cape York as an entire natural system, rather than looking within the Peninsula for the most valuable portions. The importance of extensive areas of vegetation to regulate recharge into the groundwater system in this monsoonal landscape was a key finding. This appears to be applicable in the Daly, in that dry season flows include a significant groundwater component, and there are important groundwater dependent ecosystems with associated wildlife here as well. Mackey *et al.* (2001) concluded that "*Maintaining the extant natural processes as a package of interconnected systems within the context of Cape York Peninsula's high natural integrity (together with the adjacent and contiguous parts of New Guinea and the Wet Tropics), represents the optimum strategy for protecting the identified globally and regionally important values*".

All other things being equal, large areas relatively unperturbed by modern technological society have profound ecological significance (Mackey *et al.* 2001). Criteria are therefore needed that enable such values to be incorporated into an assessment of natural heritage significance of the Daly. A number of policy decisions have been made in recent years to protect the natural values of places such as Cape York Peninsula, the Paroo River and Cooper Creek, which were recognised as national treasures for surviving thus far the advancement of major technological changes. These decisions were made as an alternative to proceeding with development to a notional "acceptable" threshold of ecological degradation, a threshold that in any case could be argued among the scientific and wider community indefinitely.

In the Daly there is the opportunity to make catchment level decisions to protect its natural integrity in the long term. The most important actions in the Daly will be the measures taken to reduce threats to the integrity of ecological processes. The greatest threats to biodiversity conservation worldwide are from habitat loss, degradation and fragmentation, and in most parts of the world these threats have already caused major losses of natural integrity and resulting breakdown of ecological processes. In much of Australia, degradation is sufficiently advanced that options to protect the natural integrity of processes are limited. In much of southern Australia we have to accept further biodiversity loss in coming decades as a consequence of past actions.

5.4 Global and national significance

As an intact landscape in the "core tropical savanna" bioclimate (Mackey *et al.* 2001), the Daly is a global rarity. Vegetation in this bioclimate in other parts of the world including India, south-east Asia, central Africa and Latin America are largely cleared. The importance of the Daly in a global context has not been assessed in the way that Cape York Peninsula (Mackey *et al.* 2001) has.

The Daly has a dry season flow that is five times greater than any other river in the Northern Territory (Price *et al.* 2003). The volume of the dry season flow affords much more than aesthetic and economic significance, it also provides significant habitat for an exceptional array of aquatic and terrestrial wildlife. There is also a very high degree of interdependence between vegetation, wildlife and an extensive limestone aquifer system.

The monsoon rainforests of the Northern Territory exist as a network of thousands of small patches (Russell-Smith and Bowman 1992), but an area of continuous riparian rainforest (about 4000 hectares) along the lower reaches of the Daly River is the largest unbroken patch of rainforest in north-western Australia (D. Franklin pers. comm.).

These values indicate that the region may have national and global significance, but assessment against detailed criteria are needed to clarify the nature of the significance of the Daly Basin's values. The unusual hydroecology of the Daly Basin and its role in maintaining various ecological (and cultural) values in particular make such an analysis desirable. It is beyond the scope of this report to make such a detailed assessment.

6. Recommendations

1. Continue the moratorium on land clearing approvals for 3-5 years. This acknowledges the irreversibility and unpredictability of the potential threat to the natural integrity of the Daly system. The development proposals are the most significant in Australia with regard to the potential impact on biodiversity and as such deserve very careful scrutiny.

2. Extend the moratorium on land clearing approvals to the whole Daly catchment.

3. Further research is required to determine the extent to which water allocation planning would be affected by the loss of over 100 000 hectares of vegetation. Comprehensive assessment of the effects of proposed groundwater extraction on the health of rainforests in the Daly is also needed.

4. Assess the natural heritage significance of the Daly catchment in both a global and national context using criteria similar to those developed by Mackey *et al.* (2001). Any local proposals that affect the global and national values of the catchment should be assessed in this context.

5. Given that broad-scale land clearing is proposed on the Douglas, Tipperary, Jindare and Claravale pastoral stations, it is vital that each of these areas are surveyed by expert biologists. Current knowledge of the wildlife status of these areas is inadequate. For instance, Claravale station was not surveyed at all for the Daly Conservation Plan (2003), yet the endangered Gouldian Finch has been recorded just 8 kilometres from Claravale's eastern boundary in recent years.

6. Create a reserve network for the Daly only after fine scale vegetation mapping is completed, which will potentially detect and enable adequate reservation of hitherto undescribed vegetation communities.

7. Recognise the interconnectedness of ecological processes across the Study Area by maintaining ecological processes across tenures, supplementing a reserve system with measures to protect the natural integrity of the catchment on unreserved land.

8. Park proposals must be devised in conjunction with landowners, particularly traditional owners.

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8 Appendices

8.1 Resources consulted

Atlas of Australian Birds II (18/8/04)
NT Wildlife Atlas (18/8/04)

Appendix 1. Significant terrestrial wildlife of the Daly Basin.

Scientific name	Common name	Threatened status		Threats		
		Aust	NT	Fire regimes	Weed invasion	Hydrological changes
Anseranas semipalmata	Magpie Goose				X	X
Amytornis woodwardi	White-throated Grass-wren		VU	X		
Erythrotriorchis radiatus	Red Goshawk	VU	VU			
Tyto novaehollandiae kimberli	Masked Owl (north Australian mainland subspecies)	VU				
Falcunculus (frontatus) whitei	Northern (crested) shrike-tit	VU				
Erythrura gouldiae	Gouldian Finch	EN	EN	X	X	
Geophaps smithii	Partridge Pigeon	VU		X	X	
Dasyurus hallucatus	Northern Quoll		VU	X		X
Phascogale (tapoatafa) pirata	(Northern) brush-tailed phascogale	(EN)	VU	X		
Conilurus penicillatus	Brush-tailed Rabbit-rat		VU	X		
Xeromys myoides	False water-rat (Water-mouse)	VU				X