Recovery plan for the mahogany glider
Petaurus gracilis

Prepared by Mark Parsons and Peter Latch for the Mahogany Glider Recovery Team

Australian Government

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Title: Recovery plan for the mahogany glider *Petaurus gracilis*

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Executive Summary

Species and Threatened Status

The mahogany glider *Petaurus gracilis* is one of Australia's most threatened arboreal mammals. It is distinguished externally from other petaurids, particularly its closest relative the squirrel glider *Petaurus norfolcensis*, by its larger size, a long and relatively short-haired tail, and buff to mahogany-brown belly. The mahogany glider is listed as 'Endangered' under the Queensland *Nature Conservation Act 1992* (NCA) and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Habitat and distribution summary

Mahogany gliders are restricted to the southern Wet Tropics of north Queensland, from the Hull River (east of Tully) south to Ollera Creek, south-east of Ingham, and extending inland about 100km. Occurring in habitat below 120m elevation, mahogany gliders are highly mobile and dependent on continuous open forest or woodland to range freely. The main determinants of suitable habitat appear to be a sufficient variety of available flowering plant species to provide year-round food. A population viability analysis suggests that a minimum area of 8000ha containing 800 individuals is required for the long term.

Threats summary

Clearing has had a dramatic impact on mahogany glider habitat, the legacy of which is a severely fragmented and modified landscape comprising patches of various sizes, shapes, connectivity and condition. Only 20 percent (106,669ha) of former habitat remains available (Kemp *et al.* 2006). Altered fire regimes, weed invasion and intensive grazing threaten the structure and ecological integrity of remaining fragments.

Isolation of populations and the decline in habitat quality are major threats to the species' survival. Open forests suitable for mahogany gliders are converting from sclerophyll forest to pioneer rainforest communities because of altered, reduced fire regimes. These changes threaten the necessary structural components (i.e. hollows, open canopy) and food sources the mahogany glider requires. Weeds exacerbate this process by inhibiting grass cover necessary to maintain fire ecotones. Weeds might also affect fire intensity and the ability of understorey fuel loads to carry fire.

The impact of grazing pressure on habitat remains unquantified. Above a tolerance threshold, grazing may degrade the understorey species composition and cover, and alter long-term canopy maintenance. The spread of weeds can also be exacerbated through grazing pressure.

Major transport corridors disrupt mahogany glider movements; a number of road kills on the Bruce Highway have been recorded. Like other glider species, mahogany gliders may die after becoming entangled on barbed-wire fences.

Overall objective

The overall aim of this plan is to improve the conservation status of the mahogany glider through habitat protection and recovery, reduced threats and public involvement.

Summary of actions

Recovery plan actions include the following:

- Update mahogany glider habitat mapping and identify areas for protection, restoration and management.
- Develop strategies to conserve mahogany glider habitat on private lands.
- Identify, manage and monitor habitats threatened by encroaching rainforest.
- Implement habitat recovery burns at key sites and improve weed control.
- Promote a mahogany glider friendly-fencing scheme.
- Reduce threats arising from transport and easement corridors.
- Determine the population genetic structure of mahogany gliders.
- Review the recovery plan.

1. General information

Conservation status

The mahogany glider is listed as 'Endangered' under the Queensland *Nature Conservation Act 1992* (NCA) and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

International obligations

The mahogany glider is not listed under any international agreements and this recovery plan is consistent with Australia's international obligations.

Affected interests

There is a range of land management uses within or adjacent to mahogany glider habitat. These include the protected area estate, improved pasture and other forms of grazing, sugarcane, caribbean pine plantations, bananas, pineapples, aquaculture and semi-rural development.

Although its distribution is restricted to the southern Wet Tropics coastal lowlands, the mahogany glider lives on land tenures owned or managed by various authorities and landholders, including:

- Environmental Protection Agency (EPA)
- Queensland Department of Natural Resources and Water (DNRW)
- Forestry Plantations Queensland (FPQ)
- Queensland Transport
- Queensland Rail
- Department of Main Roads
- Powerlink and Ergon Energy
- Hinchinbrook & Cardwell Shires
- Aboriginal communities, councils and representative bodies
- Local community conservation groups
- Peak conservation groups including Wildlife Preservation Society Queensland (WPSQ).
- Scientific research organisations including CSIRO and universities
- Private landholders.

Wet Tropics Management Authority (WTMA), QPWS FPQ, and Far North Queensland Natural Resource Management Ltd (FNQ NRM Ltd) also have involvement in land management issues and activities associated with mahogany glider conservation.

The recovery plan recognises the multiple land uses and values within the mahogany glider's distribution so wherever possible, recovery actions are designed to advance the aspirations of all interested parties. The mahogany glider recovery team comprises representatives of groups affected by the plan. All actions are designed to include land managers and/or landholders, including Traditional Owners, on any land directly affected by the actions.

Consultation with Indigenous people

Implementation of the plan's actions includes consideration of the role and interests of Indigenous people in the mahogany glider's conservation. Aboriginal communities have been and will continue to be consulted in the development and implementation of this recovery plan. Girringun Aboriginal Corporation are included on the recovery team. They represent Traditional Owners in the southern Wet Tropics including the five tribal groups on whose country mahogany gliders are found.

Benefits to other species or communities

The southern Wet Tropics coastal lowland forests contain threatened species and regional ecosystems that could be linked to mahogany glider recovery (Table 1). Measures to protect mahogany glider habitat and to mitigate threats will also help to protect many other threatened species and ecosystems. The recovery of mahogany glider populations also focuses attention on regional land management issues, such as wildlife corridors, clearing, habitat fragmentation and rehabilitation projects.

Table 1: Threatened species and ecosystems associated with mahogany glider habitat.

Common name	**Scientific name**	**Conservation status**	
Fauna		**NCA** [1]	**EPBC** [2]
Apollo jewel butterfly	*Hypochrysops apollo apollo*	E	
Lesser sooty owl	*Tyto tenebricosa*	R	
Rufous owl	*Ninox rufa queenslandica*	V	
Southern cassowary	*Casuarius casuarius johnsonii*	E	E
Crimson finch	*Neochmia phaeton evangelinae*	V	V
Spectacled flying fox	*Pteropus conspicillatus*	LC	V
Ghost bat	*Macroderma gigas*	V	
Greater large-eared horseshoe bat	*Rhinolophus philippinensis*	E	E
Diadem leaf-nosed bat	*Hipposideros diadema*	R	
Golden-tipped bat	*Kerivoula papuensis*	R	
Bare-rumped sheathtail bat	*Saccolaimus saccolaimus nudicluniatus*	E	CE
Flora			
palm	*Livistona drudei*	V	
ant plant	*Myrmecodia beccarii*	V	V
orchid	*Calochilus psednus*	E	E
orchid	*Genoplesium tectum*	E	E
Swamp orchid	*Phaius tancarvilleae*	E	E
Leafy hyacinth orchid	*Dipodium ensifolium*	R	
orchid	*Eulophia bicallosa*	R	
orchid	*Habenaria divaricata*	R	
orchid	*Habenaria rumphii*	R	
orchid	*Habenaria xanthantha*	R	
orchid	*Pachystoma pubescens*	R	
Honeydew plant	*Drosera adelae*	R	
Regional ecosystems	**Description**	**Status under VMA** [3]	
RE 7.2.4	Open forest and woodland on old stranded dune ridges	Of concern	
RE 7.3.6	Swamp paperbark and rainforest complex on very wet and poorly drained lowlands	Endangered	
RE 7.3.7	Coastal floodplain forest red gum/melaleuca open forest complex on moist to very wet poorly drained lowlands	Endangered	
RE 7.3.12	Forest red gum woodland on very wet and poorly drained lowland alluvial soils	Endangered	
RE 7.3.19	Pink bloodwood or Moreton Bay ash +/- forest red gum open forest (or vine forest with these species as emergents). Well-drained alluvium.	Of concern	
RE 7.3.20	Pink bloodwood and turpentine, or C. intermedia and red stringybark, or Syncarpia glomulifera and Allocasuarina (sheoak) spp., or Gympie messmate, or cadaghi open forests (or vine forests with these species as emergents). Moderate to steep alluvial fans at the base of ranges.	Of concern	
RE 7.3.21	Gympie messmate or white mahogany open forest on dry well-drained piedmont fans	Of concern	
RE 7.3.25	Melaleuca leucadendra (weeping tea tree) +/- vine forest species, open to closed forest. Stream levees and prior streams on well-drained sandy clay loam alluvial soils.	Of concern	
RE 7.3.26	Riparian *Casuarina cunninghamiana* open forest on channel benches, levees and terraces	Endangered	
RE 7.3.39	Forest red gum +/- poplar gum +/- pink bloodwood +/- swamp mahogany open woodland to open forest, and associated sedgelands and grasslands. Broad swampy drainage depressions of uplands.	Of concern	
RE 7.3.40	Forest red gum open forest. Well-drained alluvial plains	Endangered	
RE 7.3.44	Molloy red box +/- Clarkson's bloodwood open forest to woodland. Alluvium, in near-coastal areas with moderate rainfall.	Endangered	
RE 7.3.46	Swamp mahogany open forest to woodland. Alluvial plains.	Endangered	

1. Queensland *Nature Conservation (Wildlife) Regulation 2006*
2. Australian Government *Environment Protection and Biodiversity Conservation Act 1999*
3. Queensland *Vegetation Management Act 1999*

CE = Critically endangered; E = Endangered; V = Vulnerable; R = Rare; LC = Least concern

Social and economic impacts

The implementation of this plan is unlikely to cause significant adverse social and economic impacts. Habitat issues and likely impact on landholders have been considered in the Coastal Bioregions Regional Vegetation Management Codes for Broadscale Clearing and for Ongoing Clearing Purposes developed under the *Vegetation Management Act 1999*. The use of economic incentives for retaining mahogany glider habitat is subject to actions in the plan.

2. Biological information

Species description

The mahogany glider *Petaurus gracilis* is an arboreal marsupial that was first described in 1883 by Charles De Vis. After not having been seen formally since 1886, some were located in 1989 on freehold land at Barretts Lagoon, 14km south-east of Tully. Further work continues to define the exact distribution of the species.

The mahogany glider is distinguished from other petaurids by its larger size, relatively short-haired long tail (340–405mm) and buff to mahogany-brown belly (Van Dyck 1993; Jackson 2000a). The mahogany glider also has a golden glow on the sectioned mendulla (the base) of individual hairs, unlike the grey colour of squirrel gliders or sugar gliders *Petaurus breviceps* (B Triggs pers comm. 2000). As with all *Petaurus* gliders, a dark to black stripe extends from the eyes to the rump. Considerable variation in the depth of dorsal and ventral toning occurs. The band of fur along the lateral anterior edge of the gliding membrane may be buff, rich orange or deep mahogany. Within the Wet Tropics the much smaller sugar glider, which lives in sympatry (occupying the same geographical location) with the mahogany glider, typically has a white tail tip, whereas the lower half of the mahogany glider's tail is black (Van Dyck 1993).

Mahogany gliders are sexually dimorphic, with males being significantly heavier and having a longer and wider head, and longer snout-vent length, and females having a significantly higher tail length-to-body-length ratio (Jackson 2000a).

Life history and ecology

Mahogany gliders are nocturnal, gliding at night between feed trees and sometimes foraging as low as one metre off the ground on grass tree *Xanthorrhoea johnsonii* flower spikes. Although principally nectarivorous, the mahogany glider relies on many food sources such as nectar, pollen, mistletoe, insects, wattle exudates and honeydew (Jackson 2001). More than 20 tree and shrub species, including eucalypts, bloodwoods, melaleucas, acacia, *Albizia procera*, and *Xanthorrhoea* flower spikes provide nectar, pollen and sap that the mahogany glider eats (Van Dyck 1993; Jackson 2001). Pollen, a major source of protein, and nectar are abundant most of the year (Jackson 2001). *Albizia procera* sap is important, particularly in summer when few tree species are in flower. Other food sources, such as acacia arils, lerps, honeydew and insects are also used more frequently in summer as the availability of blossom and nectar wanes (Jackson 2001).

Mahogany gliders use hollows as dens for sleeping and rearing their young. They den either alone or in pairs (Jackson 2000b). Up to 10 dens, usually lined with a thick mat of eucalypt leaves, may be used during a single season by one individual (Van Dyck 1993, Jackson 2000b), while pairs used six to 13 dens, sharing them with offspring of the previous breeding season (Jackson 2000b). Individuals studied by Van Dyck (1993) preferred certain dens but regularly used widely separated dens throughout their home ranges. Den-tree species usually include *Eucalyptus platyphylla, E. tereticornis*, *Corymbia intermedia* and *C. clarksoniana* (Jackson 2000b).

Mahogany gliders appear to be socially monogamous (Jackson 2000b) although extra-pair matings occur (Van Dyck 1993). Individuals often den with a mate and actively mark and defend their home ranges by chasing out other mahogany gliders (Jackson 2000b). Home ranges of paired males and females overlap (about 86 percent) but less often between a mated pair and other individual mahogany gliders (about 12 percent).

In continuous habitat, males and females maintain average territories of 19.25ha and 20.34ha respectively, while territories average only 11.06ha and 6.80ha in fragmented habitat. Territories of mated pairs average 23.18ha in continuous habitat and 11.62ha in fragmented habitat. Persistence time of individuals in fragmented habitat is low (less than 12 months), depending on the fragment size and hence food and nest availability (Jackson 2000b).

Jackson (2000b) found that both sexes travelled an average of 1506m (range 590–3430m) per night but further in spring and summer than in winter. They usually forage alone, possibly to avoid predators such as rufous owls (*Ninox rufa*) and masked owls (*Tyto novaehollandiae*) (Van Dyck 1993, Jackson 1998). Although largely non-vocal, they are known to emit a "gurgle" call before emerging from a communal den. In rarer situations, mahogany gliders give alarm calls in response to owl calls comprising a single bark similar to that of the squirrel glider (Parsons, personal observation 2005).

Trapping studies suggest that mahogany gliders first breed at around 12–18 months and wean their young after 4–5 months (Jackson 2000a). They appear to be generally unable to raise more than one litter per breeding season though they might produce another if the first is lost (Jackson 2000a). The average litter size is 1.55 young, usually born between April and October. However, the discovery of hairless pouch young at Barrett's Lagoon in February by Van Dyck (1993) suggests that birth and weaning times might vary with food availability (Jackson 2000a). After weaning, juveniles of both sexes appear to disperse from the parental home range before the weaning of next year's young (Jackson 2000a).

Distribution

The geographic range of the mahogany glider is limited to an area of coastal lowland forest between Ollera Creek and the Hull River, a north-south range of about 120km (Jackson and Claridge 1999). The 100km east-west range extends from the coast to the lower Herbert Gorge and foothills of the Mt Fox section of Girringun National Park in the Wet Tropics Bioregion.

Clearing has greatly reduced and severely fragmented available habitat to 20 percent (106,669 hectares) of the original extent (Eyre 1993, Lyon 1993, Van Dyck 1993, Blackman *et al*. 1994, Jackson 1998). It is now restricted to the coastal foothills of the Paluma, Seaview and Cardwell Ranges, plus fragmented habitat scattered over the Halifax Bay, Herbert, and Murray floodplains. About 45 percent of essential habitat lies within protected area estate of Hinchinbrook and Cardwell shires (Kemp *et al.* 2006).

Over 98 percent of mahogany glider sightings have been recorded at altitudes below 120m elevation (Blackman *et al*. 1994; Van Dyck 1995, EPA unpublished data). Sightings above 120m (maximum 200m) are limited to spotlight records in Lannercost State Forest and the headwaters of the Stone River, Seaview Range. A three-week trapping survey over the Mt Fox section of Girringun National Park of sites between 80m and 460m altitude detected mahogany gliders at only 100–120m elevation (EPA unpublished data 2005).

Jackson and Claridge (1999) modelled the distribution of the mahogany glider and squirrel glider. Although closely related, they are known to be geographically isolated. The model demonstrated that the predicted mahogany glider distribution does not exceed the known range based on sightings. There is, however, a predicted overlap of the squirrel glider into mahogany glider habitat. The closest known populations of mahogany and squirrel gliders are approximately 25km apart (Jackson and Claridge 1999).

Habitat critical to the survival of the species

As clearing has reduced and severely fragmented glider habitat, any remaining habitat still used by mahogany gliders is considered critical to survival. This habitat occurs in the southern Wet Tropics coastal lowlands below 120m elevation except in isolated cases (Kemp *et al.* 2006, Burnett 1998). Two types of vegetation present formidable ecological barriers for the western and southern boundaries of the species' distribution. They are upland rainforest, typically the dominant vegetation

community along the escarpment of the Paluma, Seaview and Cardwell Ranges, and the drier Einasleigh woodlands to the south of Saltwater Creek.

As mahogany gliders are highly mobile, they depend on continuous open forest or woodland to range freely. However with their habitat severely fragmented, narrow strips of forest or woodland remnant sclerophyll vegetation may be the only link to larger forest tracts and other isolated populations, and with it, genetic interchange.

The distribution of habitat has been identified and mapped by EPA (Figure 1), and is based on Regional Ecosystem (RE) v 5.0 mapping. Mahogany glider habitat is protected and defined as 'essential habitat' under the *Vegetation Management Act 1999* and under the Coastal Bioregions Regional Vegetation Management Codes for Broadscale Clearing and for Ongoing Clearing Purposes.

Important Populations

There are five large habitat areas and three smaller habitat fragments currently recognized within the distribution of the mahogany glider from a conservation planning perspective. Though various surveys have been conducted within representative sites of these habitat areas, population numbers are not known within these areas, nor across the distribution of the species.

A population viability analysis suggests that a minimum of 8000ha containing 800 individuals is required for a population to be viable in the long term (Jackson 1999). Naturally, smaller areas have small, isolated populations and a consequently low chance of long-term survival. Based on this analysis and a GIS assessment of available habitat, five existing geographic areas are tentatively considered large enough to support populations in the long term (Table 2).

The strength of links within these areas and the barriers to dispersal between fragments or across into continuous habitat are however unknown. It is clear however that habitat linkages of areas three, four and five, in particular, must be repaired, maintained and managed for populations to be able to disperse and remain functional across these areas and onto adjoining populations.

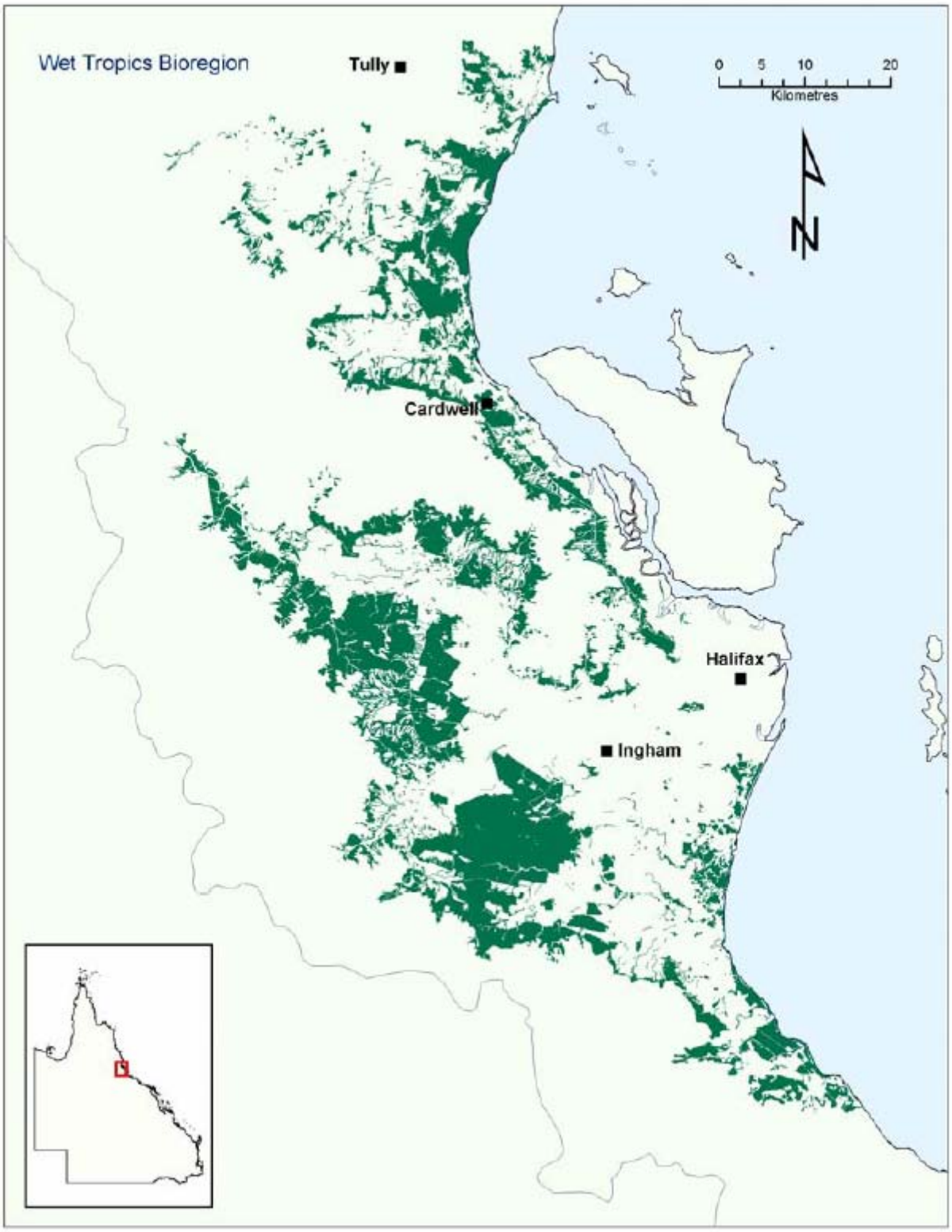
Because the population structure of the mahogany glider has not been able to be analysed, no data are available to determine three facts: (i) the extent to which the population consists of smaller disjunct subpopulations; (ii) the barriers to dispersal and gene flow; and (iii) the extent to which fragmentation has isolated populations.

Three smaller, heavily fragmented and isolated areas of habitat exist (Table 2). Whether they can be designated as subpopulations or that they might support viable populations is unknown. These areas could be important reference points for a metapopulation study (see Action 5.1) which would examine key threatening processes, such as isolation, in small populations.

Table 2: Areas supporting mahogany glider populations

Area name	**Location**
Large habitat areas	
1. Wharps Holding - Paluma Range	South of Stone River including Bambaroo Hills and Paluma Range
2. Lannercost - Henrietta	South of the Herbert River west to foothills of Seaview Range
3. Yamanie - Cardwell Range west	North of the Herbert River east to Cardwell Gap
4. Cardwell Range east	Cardwell Gap north to the Kennedy Valley
5. Cardwell coastal region	Meunga Creek to the Tully River
Small, isolated and highly fragmented areas	
6. Halifax Bay	Coastal complex east of the Bruce Hwy from Crystal Creek north to Lucinda
7. Hull Heads	North of the Hull River
8. Murray floodplains	West of the Bruce Hwy, north of Bilyana to Euromo

Figure 1: Distribution of mahogany glider habitat in Australia



The information shown on this map is for discussion purposes only. Not for reproduction or distribution.
Data sources:
Mahogany glider habitat:
Environmental Protection Agency.
Derived from Regional Ecosystem Database v 4.0
Produced Dec 2005 EPA/QPWS Atherton

Mahogany glider habitat
Biogeographic Regions (IBRA)

Queensland Government
Environmental Protection Agency
Queensland Parks and Wildlife Service

3. Threats

Biology and ecology relevant to threats

The mahogany glider is cryptic, elusive and virtually silent (Van Dyck 1995). These features hinder surveys to estimate total population size and to determine the southern, western and northern distribution limits. Consequently, there are no published data on total abundance or distribution limits beyond records-based modelling and ad hoc surveys at and beyond the edge of current known records.

As the second largest Petaurid glider, the mahogany glider requires a more open forest structure for efficient gliding than the sympatric sugar glider. The average heights and distances are (Jackson 2000c):
Mahogany glider: (average glide distance 29.71m ± 2.38m, average launch height 19.75m ± 1.01m, average landing ht 4.48m ± 0.31m
Sugar glider: (average glide distance 20.42m ± 1.33m, average launch height 11.96m ± 0.48m, average landing ht 1.95m ± 0.17m) (Jackson 2000c).

These figures indicate a habitat partitioning between the two species with Jackson (2000d) observing a higher density of mahogany gliders in continuous forest and conversely a higher density of sugar gliders in the adjoining fragmented habitat. Fragmented habitat often has a dense mid-storey of pioneer species such as acacia thickets that are likely to hinder the efficient gliding of the larger mahogany glider (Jackson 2000c).

As the mahogany glider is territorial, even marginal habitat is likely to be defended by a remnant population of gliders until suitable resources are exhausted. Consequently, recovery options such as the selective re-introduction of captive reared mahogany gliders is likely to be problematic, given that potential sites are highly likely to already be occupied by a resident population. Given that the threat to the mahogany glider is largely the loss or deterioration of remnant vegetation, captive breeding for larger scale recovery release purposes is unlikely to be viable.

Much of the current ecological knowledge drawn upon to understand the habitat and requirements of the mahogany glider is limited to that work undertaken by Dr Steve Van Dyck (1993) and Dr Stephen Jackson (1998) and subsequent publications. It is not known whether there are unique characteristics or subtle variations within other populations outside these studied areas. It is apparent however that low detection rates are also recorded by survey efforts in other localities (QPWS unpublished data).

Identification of Threats

Habitat loss and fragmentation

Clearing is one of the most serious threats to the long-term viability of mahogany glider populations. As identified in the previous recovery plan (EPA/QPWS 2001), it has had a dramatic impact on habitat and a corresponding reduction in distribution and connectivity of the species. About 20 percent of former available habitat remains. Data on vegetation loss in the Wet Tropics bioregion indicate that large-scale clearing has been substantial but largely historical, slowing in the past decade to a rate of 1007ha/yr in 1999-2001 (DNRM 2005). Recent habitat loss has not been assessed.

The *Vegetation Management Act 1999* through the Wet Tropics Vegetation Management Codes regulates and restricts clearing of remnant mahogany glider habitat. Urban residential development pressures in some areas threaten habitat as small blocks or parts of supporting mahogany glider habitat have been cleared or severely modified. In an area where habitat is already severely fragmented, small incremental losses over time may eventually lead to a landscape matrix not able to support local mahogany glider populations. The extent to which incremental loss of habitat as a major threat warrants further analysis.

The legacy of clearing, and one of the most serious threats to the long-term viability of mahogany glider populations, is a severely fragmented and modified landscape comprising patches of habitat of various sizes, shapes, connectivity and condition. Fragmentation disrupts the movement paths of mahogany gliders, may segregate feeding and breeding sections of an individual's range and may

predispose the species to genetic isolation and local extinctions. Fragmented mahogany glider habitat is particularly evident on the Halifax Bay, Herbert and Murray floodplains. Two important mahogany glider Regional Ecosystems, RE 7.3.19 and 7.3.25a are among the worst affected areas of remnant vegetation of these floodplains.

Habitat degradation and alteration

Altered fire regimes, weed invasion and intensive grazing, individually or collectively threaten the structure and ecological integrity of habitat fragments. Over time these changes decrease the ability of fragments to support glider populations. The decline in habitat quality is one of the major threats to the mahogany glider.

a. Intensive grazing and weed invasion

Cattle grazing occurs in some areas of mahogany glider habitat, predominantly on the western distribution of the species, but the impact on mahogany glider habitat remains unquantified. At stocking rates above a tolerance threshold, grazing pressure may degrade the understorey species composition and percentage cover, and alter long term canopy maintenance. Cattle grazing and weed invasion are also thought to affect fire intensity and the ability of understorey fuel loads to carry fire. Cattle can eat or damage the young flower stalks of *Xanthorrhoea johnsonii*, which are important sources of nectar and pollen that bloom at a time when other food resources are unavailable (Van Dyck pers. com.). These threats could be addressed through determining desirable grazing regimes and stocking rates that simultaneously maintain long-term viability of glider habitat while taking into account the economic viability of properties.

Weeds of particular concern within mahogany glider habitat include Siam Weed *Chromolaena odorata* and Sicklepod *Senna obtusifolia*, however Lantana *Lantana camara* is prevalent within most habitats. These three weeds possess a strong ability to colonise disturbed sites and can be exacerbated through grazing pressure. If untreated in the long term they could diminish mahogany glider habitat integrity; particularly along the highly sensitive *E. tereticornis* and *Lophostemon suaveolens* terrace communities (RE 7.3.19) that often provide habitat linkages.

b. Open forest and woodland thickening through altered fire regimes

Fire frequency and intensity influence forest structure and species composition in lowland forests of the Wet Tropics bioregion. A prevailing fire regime that is too early in the fire season will not maintain an overall open forest structure essential to mahogany gliders, whereas a fire regime that is too frequent will gradually simplify the plant structure and promote a grassy understorey which is detrimental to mahogany glider habitat.

For the southern Wet Tropics coastal lowlands, an absence of fire leads to a rapid transition from an open forest or woodland to a closed forest dominated by rainforest species (known as woody thickening), while infrequent but intense fire may promote acacia thickening. Whilst there is a degree of natural fluctuations along ecotones maintained by fire, open forests suitable for mahogany gliders are converting from sclerophyll forest to pioneer rainforest communities because of altered, reduced fire regimes (Van Dyck 1993). These structural changes to open forest communities reduce the efficiency of gliding, threaten the necessary structural components (i.e. hollows, open canopy) and food sources required by the mahogany glider.

Though there is little available data on the rate and extent of encroachment within mahogany glider habitat, regional ecosystems such as 7.3.19 are prone to these gradual changes. Pioneer species such as *Melicope alleryana*, *Alstonia muerelliana and Acacia mangium* are indicators of such change. Weeds, predominately lantana but also Chinese Burr *Triumfetta rhomboidea*, Sicklepod and Siam Weed, exacerbate this process by inhibiting grass cover necessary to maintain fire ecotones. Such weeds in larger infestations can also affect key food resources as *Albizia procera*.

Transport and easement corridors

Apart from natural predation or habitat loss, major transport corridors are the single largest known contributor to mahogany glider fatalities; thirteen road kills were recorded from 1991 to 2007 (Parsons 2007, Smith 1996). Almost all road kills were recorded on the Bruce Highway and appear to be juveniles, suggesting that the road's width is a formidable barrier to dispersal. In places where the

QRail corridor or CSR tram-line run parallel, the highway can be 60 metres wide. This is at the maximum glide distance and twice the average glide distance recorded by Jackson (2000c) for the mahogany glider. Mosquito Creek (south of Bambaroo) and Easter Creek (south of Helens Hill) are also known road kill sites. At Bambaroo Hills, mahogany gliders are known to utilize power poles on the edge of the Bruce Highway to cross, where the gliding distance is less than 40 metres (Parsons and Asari, unpublished report 2007).

Fencing

Mahogany gliders, like other glider species, become entangled in barbed-wire fences. From May 1994 to October 2007, eleven barbed-wire entanglements were recorded, five of which were fatal. Typically, they become entangled on the top strand, with the delicate patagium (gliding membrane) often quickly entwined. With all known incidents occurring over late spring/summer, dehydration and/or starvation were a likely consequence (Parsons 2007). Some sites pose the greatest risk of entanglement where fencing dissects sparsely distributed tall trees, and where glides are likely to be longer than 20 metres.

Feral predation

To date, only one cat and two dog attacks on mahogany gliders have been reported to EPA (Lyon 1993, Parsons 2007). Since people probably don't observe attacks, the two reports may not reflect the actual rate. For example it is known that cats attack both sugar and squirrel gliders. It is also possible that these might be opportunistic attacks on weakened animals as a consequence of other factors such as habitat fragmentation.

Areas and populations under threat

The home ranges of mahogany gliders in continuous forests are twice as large as those in habitat fragments. Individuals are more persistent there than in fragments, which have lower mahogany glider densities (Jackson 2000b). This suggests that dispersing subadults and young adults probably occupy forest fragments or marginal habitats temporarily. Fragments alone seem to be unable to support a population in the long term.

Key areas where fragmentation may be of concern include Lannercost, Abergowrie and Cardwell State Forests. Issues revolve around reduced fire frequencies in remnant corridors which promotes vegetation thickening. The reduction in fire frequency in such cases is largely due to the difficulties in securing key firebreaks from the plantation boundary, into suitable areas where conservation based habitat recovery burns can be safely undertaken. Fragmented habitat through clearing or dissection is also a concern for such areas as Bambaroo Hills, Easter Creek, and north of Cardwell along the Murray River floodplain (Meunga Creek, Whitfield Creek).

Given its restricted and fragmented distribution the overall population of the species is considered to be under threat from a variety of sources. Five broad habitat areas have been identified, but habitat links may be tenuous and under threat. However, there is insufficient data to confirm this. A lack of data also hinders progress on other issues: determining the population structure; identifying specific threats to individual populations; and the extent to which the three coastal plains fragments can support viable populations.

4. Evaluation of the previous recovery plan

1. Recovery organisation

1.1 Recovery team operation

The recovery team met four times during the life of the previous plan. The majority of discussions centred on the development of the draft Mahogany Glider Conservation Plan as that was seen as the major tool for securing remaining mahogany glider habitat on leasehold land. The Recovery Team was well represented by major stakeholder groups and was a good forum for debate on recovery issues.

1.2 Recovery coordination

Recovery actions were coordinated by EPA officers and included ongoing management of the mahogany glider sightings database, habitat mapping (including essential habitat mapping), preliminary work to identify habitat linkages, identification of habitat corridors for recovery burns and production and delivery of education and extension material.

2. Habitat protection and management

2.1 Declaration and acquisition of habitat into protected area estate

About 10,000ha of remnant vegetation, including mahogany glider habitat was added to Edmund Kennedy National Park. There were also numerous smaller additions to Girringun and Paluma Range national parks.

The Wet Tropics transfer process involving tenure conversion of remnant areas within state forests across to national parks also occurred.

2.2 Maintaining habitat patches and restoring habitat linkages with voluntary conservation agreements on unprotected freehold land

Three new nature refuges supporting mahogany glider habitat (Mahogany Glider Nature Refuge, Seafarm Nature Refuge and Chakoro Nature Refuge were declared over the period of the previous recovery plan and EPA continued to liaise with the landholders of existing nature refuges.

2.3 Ensuring the survival of the species on protected areas, state forest and state land

From 2004 under the state government fire initiative special allocation for protected areas, funding at a level of $58,500 over 3 years has been directed towards the following activities:

- Improving firebreak access for the Henrietta section of Girringun National Park, and Lannercost and Abergowrie state forests.
- Identifying and implementing specific recovery burns for remnant corridors adjacent to pine plantations through Lannercost, Abergowrie and Cardwell state forests.
- Undertaking aerial ignition throughout the lowland areas of the Seaview and Cardwell ranges to reduce the risk of late season wildfire canopy scorch in mahogany glider habitat, and to promote a mosaic fire pattern and interval.

From 2004 under the state government pest initiative special allocation for protected areas, funding at a level of $110,000 over 3 years has been directed toward the following activities:

- Control of key weed infestations in remnant corridors within Clemant and Abergowrie State Forests and within the Henrietta section of Girringun National Park.
- Continuing and expanding upon feral animal control programs involving the removal of feral cattle within the Henrietta and Yamanie sections of Girringun National Park. Since 2003, more than 500 head of cattle have been removed from these areas. This has reduced this source of disturbance for the spread of Sicklepod, Lantana and Knobweed further into mahogany glider habitat.
- Initiating weed hygiene measures for vehicle access and hiking along the Great Walk route though the Henrietta and Herbert River Gorge sections of Girringun National Park.

3. Monitoring

During the life of the previous recovery plan survey work has progressed towards establishing permanent repeatable trapping transects, at determining the southern and western distribution of the species, and at implementing target surveys to investigate residual remnant populations within isolated habitat fragments. Due to the cryptic nature of the species and its low trappability, there is not sufficient information to determine a baseline population size, let alone increases or decreases in local populations .

Over the period of the previous recovery plan the following monitoring efforts have been progressed by EPA:

- Mahogany glider surveys have continued to examine the distributional limits of the species resulting in an extension to the south and west of previous known range.

- Ongoing information supports the known altitudinal limit of the species as being below 200m asl.
- Survey work in areas such as the Bambaroo School block, Venables Crossing, Byabra Creek and Corduroy Creek indicate that resident small populations persist in isolated fragmented habitats.
- Permanent survey sites have been initiated in Jourama Falls section of Paluma Range National Park, the Henrietta section of Girringun National Park and the Broadwater Hill section of Abergowrie State Forest allowing comparisons to be made to data obtained from previous survey work, particularly the Porters Creek study site of Jackson (1998).
- A range of volunteer groups, such as Conservation Volunteers Australia, Greencorps, Australearn, and university student participants have been involved with implementing mahogany glider surveys, and in weed control activities within mahogany glider habitat on protected area estate.
- A review of known injured mahogany glider encounters, including cause and seasonality patterns, was undertaken by EPA.

4. Research

4.1 Determining appropriate management, grazing and fire regimes

Representative fire monitoring plots have been initiated on protected area estate to monitor the fire response of individual flora species and to identify encroaching species. EPA maintains a fire history database for planned burns and wild fires over areas of mahogany glider habitat. A pilot study to investigate the gradual encroachment of rainforest pioneers into mahogany glider habitat has been undertaken by the EPA/ QPWS (Queensland Herbarium) (Appelman 2006). This is to inform on-ground habitat management initiatives. Work has yet to commence on grazing impacts.

4.2 Improved pasture management and habitat response

This research project has not commenced.

4.3 Vegetation corridors

Preliminary work to identify habitat linkages has been initiated. Survey work has been undertaken in selected corridors to investigate whether resident mahogany gliders persist and the nature of disturbance which may operate in these corridors.

Tree plantings with compatible species to enhance mahogany glider corridors identified by the Herbert River Catchment Management Group and implemented by Greencorps have occurred in the following properties: Bonassi/ Gap Creek Road; Bambaroo Billabong; Mario Porta's; Zatta's; Lacini's; Lemon Tree Swamp; and Damon Side.

4.4 Production of habitat utilisation map

While the habitat utilisation map was not finalised the following occurred:

- A review of the original mahogany glider distribution mapping was undertaken in line with changes to Queensland Regional Ecosystem mapping and the new records of sightings incorporated. This included re-modelling through BioCLIM with new records, and patch analysis of suitable habitat fragments.
- Mahogany glider essential habitat mapping under the *VMA* was produced and finalised.
- Preliminary work to identify a habitat seasonality rating was initiated by the MGSAG.

4.5 A genetics study to determine metapopulation structure.

A PhD study on the genetics of mahogany glider populations involving Melbourne Museum, James Cook University and EPA commenced in 2005. The results of this study will be released for publication and be made available to the Recovery Team and MGSAG.

5. Public information and education

5.1 Involving community action groups

A Mahogany Glider Education Kit ('Rescue the rope dancer') was developed by WPSQ (Tully branch) which has since been adopted by Education Queensland for use in primary schools. Various interpretive materials and media releases have been prepared and distributed to local outlets.

Several information sessions on mahogany gliders have been presented by WPSQ and EPA at the request of local schools and community groups, reflecting an increased public awareness of the conservation issues and efforts for this species.

There has been an increased level of reporting of injured mahogany glider encounters to both EPA and WPSQ wildlife carers. This reflects an increased level of openness and awareness of landholders to mahogany glider conservation issues.

5.2 Community involvement in habitat rehabilitation

In 2001 a tree nursery program involving primary schools from Hull River, Murray Upper, Kennedy, Ingham and Bambaroo, was initiated through WPSQ and EPA. Corridor plantings through this program occurred in such areas as Yabullum Nature Refuge and the Bambaroo school environmental reserve. Bambaroo State School has also for three years running (2004, 2005, 2006) won the Keep Australia Beautiful Council Nth Qld Region Comalco Green and Healthy School – Protection of the Environment award for mahogany glider corridor planting and associated awareness education for its students.

Artificial den boxes have been promoted by WPSQ and installed at selected sites of habitat fragmentation on freehold property and protected area estate within the Cardwell area with the support of landholders. These are known to be used by mahogany gliders, though such boxes provide augmentation only at a local site level for individual animals to assist dispersal.

5. Recovery objectives, performance criteria and actions

Overall objective

To secure and improve the conservation status of the mahogany glider through an integrated program of habitat protection and improvement, threat abatement and public awareness and involvement.

Specific Objective 1 Identify and prioritise areas of mahogany glider habitat for protection, management and recovery

Action 1.1 Update mahogany glider habitat mapping as required

Performance criterion 1.1: Distribution of mahogany glider habitat map reviewed, updated and made available to staff involved in management.

The current distribution map of mahogany glider habitat is based on Qld Herbarium Regional Ecosystem (RE) 1:100,000 mapping Version 5 overlayed with known records, BioClim modelling and refinement such as patch analysis (Figure 1). This map will be updated using the latest RE coverage, new glider sightings information and the mapping methodology described by Kemp *et al.* (2006). The process should also identify and map rehabilitating habitat. Rehabilitating habitat represents non-remnant vegetation in the landscape, including disturbed or regenerating habitat, that retains habitat or potential corridor values for the mahogany glider. While not protected under legislation, these areas may be targeted for future restoration work as identified in Action 1.3. Mapping will be reviewed on a biannual basis.

Potential contributors: EPA, Mahogany Glider Scientific Advisory Group (MGSAG), Wet Tropics Management Authority (WTMA).

Action 1.2 Assess habitat areas for priority protection and management

Performance criterion 1.2: Mahogany glider priority conservation areas identified for management action and implementation commenced.

EPA mapping identifies habitat but not specific areas or populations that need to be targeted for conservation. The distribution map serves as a baseline for more detailed plans. After Action 1.1 has

been completed, priority conservation areas or populations will be identified and the condition of key fragments assessed. Assessment criteria will be developed to ensure priority ranking is consistent and defensible. These criteria will consider habitat fragmentation and other threats, planning and development issues, glider ecology and Regional Ecosystem conservation status. A schedule of recommended priorities with costings and potential contributors will be presented to the recovery team for action.

Potential contributors: EPA, MGSAG, WTMA.

Action 1.3 Identify and prioritise habitat corridors for protection, restoration and management
Performance criterion 1.3: Priority habitat corridors identified, assessed, mapped and action plans completed.

To link isolated populations and facilitate movement of mahogany gliders between fragments for feeding, breeding and dispersal, a network of habitat corridors across the landscape needs to be established. Cardwell Shire Council is identifying wildlife corridors and land parcels requiring conservation management and habitat links have been identified by the Wet Tropics Conservation Strategy (WTMA 2004).

This action will build on these strategic corridors to develop more detailed corridor plans identifying specific areas for conservation and to recommend appropriate management requirements. Actions 1.1, 1.2 and 5.1 will inform this process. The plans will prioritise actions, assign costs and identify potential participants and funding sources.

Potential contributors: EPA, MGSAG, WTMA, Far North Queensland Natural Resource Management body (FNQNRM), local councils, community groups, Traditional Owners.

Action 1.4 Identify and implement strategies to conserve mahogany glider habitat on private lands
Performance criterion 1.4: Conservation measures for private land identified, matched against priority conservation areas and strategies implemented.

Although 45 percent of available mahogany glider habitat is now conserved within protected estate in Hinchinbrook and Cardwell Shires, recovery will be more effective if remnant and connecting habitat on private lands are also managed for mahogany glider conservation.

Building on Actions 1.2 and 1.3, this action will investigate strategies and conservation incentives to involve landholders. Non-regulatory financial incentives include grants, rate deferrals and rebates, conservation or management agreements, covenants, revolving funds and development benefits. Industry codes of practice, such as native forest harvesting on freehold land, or State Planning Policies will be considered.

The community and local authorities will be consulted to identify habitat protection options, canvass opinion, determine funding requirements and evaluate implementation strategies for preferred options for habitat protection on private lands.

Potential contributors: EPA, FNQNRM, local councils, community groups, Traditional Owners.

Specific Objective 2 Improve mahogany glider habitat by managing grazing, fire and weeds

Action 2.1 Identify and assess habitats threatened by encroaching rainforest
Performance criterion 2.1: Habitats threatened by encroaching woody thickening and pioneer rainforest assessed and report prepared.

The thickening of vegetation caused by altered fire regimes is threatening mahogany glider habitat but the rate and extent have not been measured, although a pilot study has been undertaken by the Qld Herbarium to determine an appropriate methodology for this assessment (Appelman 2006).

This action will assess the rate and extent of rainforest encroachment in mahogany glider habitat, targeting key sites throughout the glider's distribution. The methodology should use air photo or satellite interpretation, GIS analysis and relevant field assessments, building on the methodology recommended in the pilot study of Appelman (2006).

Potential contributors: EPA, MGSAG, WTMA, FNQNRM, local councils, community groups.

Action 2.2 Implement habitat recovery burns at key sites
Performance criterion 2.2: Habitat recovery burns implemented at key sites.

Mahogany glider habitat is fire dependent, generally relying on a mosaic regime of less than five-year intervals to maintain an open forest. The threat of rainforest encroachment from less frequent fires may be amplified within corridors.

An implementation schedule will be developed and, in consultation with protected area managers, recommendations incorporated into fire planning for identified areas. Corridor burn areas will be identified in the first two years of this plan, following Actions 1.3 and 2.1. Preparations for burns in protected estate, particularly adjoining or within state forests, should be properly resourced (e.g. construction and maintenance of firebreaks in Lannercost, Abergowrie and Cardwell State Forests).

Potential contributors: EPA, Forest Plantations Queensland Department (FPQ), local councils.

Action 2.3 Improve weed control in mahogany glider habitat
Performance criterion 2.3: Existing weed management plans audited and recommendations for implementation provided to relevant authorities and landholders.

The Wet Tropics Conservation Strategy and the Wet Tropics NRM Plan recommend actions against environmental weeds, including weeds threatening mahogany glider habitat (WTMA 2004, FNQ NRM Ltd and Rainforest CRC 2004). Local governments have developed Pest Management Plans for major weeds. These plans are part of a Regional Pest Management Strategy for Far North Queensland Regional Organisation of Councils. There are also weed management plans and programs for protected area estate.

This action will support measures in the above plans by coordinating weed management. An audit of existing programs will be conducted to determine the effectiveness of on-ground work, following an assessment of fragment conditions (see Action 1.2). A line of communication will also be established through which outcomes of monitoring, research and other recovery actions that may impact on or inform control programs can be disseminated to relevant authorities.

Potential contributors: EPA, FNQNRM, local councils, landholders.

Action 2.4 Engage private landholders in developing land management practices that balance mahogany glider conservation needs with other land uses
Performance criterion 2.4: Extension program established for landholders outlining appropriate fire, grazing and weed management practices in mahogany glider habitat and these management practices are implemented.

In this action, landholders and industry groups will help develop management practices that balance mahogany glider conservation with other land uses. It may be done as a case study with workshops and 'plain English' brochures of appropriate management practices for fire, grazing and weeds. The information will be gathered in Actions 1.3, 2.1, 2.3 and 5.3; and for incorporation of Aboriginal knowledge of fire management, in Action 6.3.

This action will match proposed projects in the Wet Tropics NRM Plan (FNQ NRM Ltd and Rainforest CRC 2004). The recovery team will work with FNQ NRM Ltd to identify and develop the best way of recovering habitat and to encourage landholders to use these practices.

Potential contributors: EPA WTMA, FNQNRM, local councils, landholders, industry groups, Traditional Owners.

Specific Objective 3 Respond to and manage problems with easement corridors, barbed-wire fences and injured gliders

Action 3.1 Reduce threats arising from transport and easement corridors
Performance criterion 3.1: Guidelines to minimise mahogany glider mortality associated with transport and easement corridors incorporated into road and powerline planning, construction and maintenance.

The width of roads and rail line or powerline easements present dispersal barriers to mahogany gliders, particularly where the width exceeds average glide distance of 30 metres. As an example of being an adaptable species, mahogany gliders have been observed to utilize power poles as crossing points across the Bruce Highway, where the glide distance is under 40 metres and these poles present the suitable features to encourage their use such as location and launch height. Mahogany glider conservation must be central to planning, construction, maintenance and upgrading of transport and easement corridors.

Develop guidelines that aim to reduce the threat from transport and easement corridors on mahogany gliders and considers:

- Liaison with State and local government road, rail and power authorities to identify opportunities to minimise impacts on mahogany gliders during all phases of planning and management.
- Construction of glider poles at known road kill sites such as Mosquito Creek (south of Bambaroo) Corduroy Creek (Murray Flats) and Easter Creek (south of Helens Hill).
- Identification of key habitat linkages and key seasonal food resources where easements dissect habitat and limit dispersal of juveniles.
- Reporting of all injuries and deaths resulting from easements/roads to EPA.

Potential contributors: EPA, FNQNRM, Dept Main Roads, power authorities, local councils.

Action 3.2 Promote a mahogany glider friendly fencing scheme
Performance criterion 3.2: A voluntary fencing scheme to reduce glider entanglements in barbed wire promoted and in place by 2011.

A mahogany glider friendly-fencing information brochure will be produced, promoted and distributed in the community. It will describe suitable land management activities appropriate to mahogany glider habitat, including fencing design such as the use of a plain wire top strand. High-risk areas will be assessed and priority sites targeted for action. Landholders will be encouraged to use a plain wire top strand when building new fences, or repairing existing fencing. Funding will be sought through such schemes as NatureAssist to reduce landholder costs for replacing barbed-wire top strands with plain wire in priority sites.

Potential contributors: EPA, FNQNRM, community groups, landholders.

Action 3.3 Develop a mahogany glider care, rehabilitation and release protocol
Performance criterion 3.3: A mahogany glider care, rehabilitation and release protocol prepared by 2008 and implemented as required.

Since adoption of the previous recovery plan, five mahogany gliders have required indefinite care due to permanent debilitating injuries, mostly involving barbed wire entanglements. These animals are now permanently housed at EPA's David Fleay Wildlife Park where they have served as stock for a reproductive biology research project. A central objective for the recovery efforts of injured glider encounters is that every effort should be made to return rehabilitated gliders to the wild, though it has to be recognised this can be on a case by case basis, made on reflection of a veterinary assessment and in respect to the animal's welfare.

As part of the reproductive biology research project undertaken by Fleay's Wildlife Park, 24 young captive reared gliders have been produced. These young should be assessed and then considered for release to the wild under the guidelines of the release component of the protocol for the welfare, rehabilitation and release of gliders. There is potential to use these animals to facilitate research (in collaboration with appropriate institutions) to determine best practice for release of gliders to the wild. This will be explored within the context of this recovery plan and implementation will be the responsibility of the MGSAG.

It is recommended that within the first year of this recovery plan a protocol be developed for the care and rehabilitation of injured mahogany gliders. The protocol will need to consider EPA policy on management of captive threatened species as well as:

- Procedures for responding to injured, orphaned or sick gliders.
- Appropriate rehabilitation and husbandry techniques including the role of veterinary care.
- Release guidelines for rehabilitated animals.

Potential contributors: EPA, local wildlife care groups.

Specific Objective 4 Monitor mahogany glider populations and their habitat

Action 4.1 Establish distributional limits of mahogany gliders, monitor populations and their habitat

Performance criterion 4.1: Monitoring of mahogany glider populations and habitat in progress, at key sites that are currently actively managed.

There is no specific long-term monitoring program for the mahogany glider although EPA has conducted a series of surveys. These surveys aim to determine the north, south, west and altitudinal limits of the species and are part of wider EPA survey programs into fire and weed issues of conserving habitat of the southern Wet Tropics coastal lowlands.

A minimum of four permanent trapping grids are planned to be established across the species distribution, with at least one survey conducted per year on a rotational basis. These sites aim to replicate the methodology of Jackson (1998). Four satellite surveys per year examining distribution limits (to the north around Hull River; to the south towards Saltwater Creek, and to the west towards Herkes Creek, Herbert River Gorge) or fragment health should run concurrently with grid surveys.

A habitat monitoring program will be established to monitor and assess management intervention at key sites. The sites will have been identified and established in part by Actions 1.2, 1.3, 2.1 and 2.3. Landholders will be encouraged to take part in the monitoring program. The pilot study developed by the Queensland Herbarium (Appelman 2006) will be assessed for its suitability to monitor mahogany glider habitat. This will be the responsibility of MGSAG.

Potential contributors: EPA, MGSAG, FNQNRM, research institutions, community groups, Traditional Owners.

Action 4.2 Assess the conservation status and population size of mahogany gliders

Performance criterion 4.2: Mahogany glider status re-assessed, depending on data.

As the mahogany glider is an elusive and cryptic species, low detection rates and few available data hinder assessment of population size and trends. Over the life of this plan, the conservation status and estimated population size of mahogany glider populations will be re-assessed by the MGSAG. This will include an analysis of trends and a review of the population viability analysis undertaken by Jackson (1999).

If a change in status is required, a nomination with supporting information will be prepared and submitted.

Potential contributors: MGSAG, MG Recovery Team, EPA.

Action 4.3 Maintain a GIS database on mahogany gliders
Performance criterion 4.3: Mahogany glider database maintained and kept current.

EPA maintains a GIS-based mahogany glider sightings database, routinely loaded onto the WildNet database to incorporate survey records, and incidental and injured mahogany glider encounters. The sightings database is also used to verify essential habitat mapping under the *VMA*, for government assessment of land development and planning, and for identifying habitat links and conservation tasks. The database will be maintained and updated regularly. Appropriate GIS layers will also be developed to inform recovery actions.

Potential contributors: EPA.

Action 4.4 Review and report on monitoring and research outcomes
Performance criterion 4.4: Regular monitoring reports completed and disseminated to appropriate agencies and groups.

EPA regularly prepares short field reports of each mahogany glider survey. These reports will continue. Annual monitoring and research reports will be given to the recovery team and management agencies. If necessary, management programs will then be revised.

Potential contributors: EPA,FNQNRM.

Specific Objective 5 Improve understanding of mahogany glider ecology and threats to its survival

Action 5.1 Determine the population genetic structure of mahogany gliders
Performance criterion 5.1: Population genetic structure and metapopulation analysis of mahogany gliders completed and a report prepared and peer reviewed.

The current examination of the population genetic structure of mahogany gliders will continue, particularly to examine the relationship between this species and the related squirrel glider and identify whether hybridisation currently occurs. Genetic samples will be collected from individuals captured during surveys, especially of both the mahogany glider and squirrel glider obtained from north Queensland. Patterns of relatedness in subpopulations will be determined across the species range and will indicate the scale of dispersal within and between populations. Information obtained will be used in developing metapopulation and population viability models that will assist in identifying habitats/corridors requiring management to facilitate dispersal.

Potential contributors: EPA, MGSAG, research institutions, FNQNRM.

Action 5.2 Assess the effectiveness of corridors in helping mahogany glider movement and rehabilitate priority corridors
Performance criterion 5.2: Mahogany glider corridor project complete and results incorporated into corridor planning actions, including rehabilitation of priority corridors.

Corridor lengths, widths and resources necessary to encourage dispersal are unknown at this stage, although the preferred species composition and desired forest structure are outlined in Jackson (1998), (2000c and d). To assess the effectiveness of corridors in helping mahogany glider movement a monitoring, research and management program will be established. Undertaken with Action 1.3, this program aims to:

- Determine the minimum fragment size, level of connectivity and habitat features for a long-term breeding population of mahogany gliders to persist.
- Determine corridor lengths, widths and resources necessary for successful movement between fragments.
- Develop techniques for long-term maintenance of habitat structure within constraints of local land uses.
- Attract external funding and support to create, rehabilitate and protect corridors and habitat remnants.

Potential contributors: EPA, MGSAG, WTMA, FNQNRM, research institutions, community groups, Traditional Owners.

Action 5.3 Investigate appropriate grazing and fire regimes in mahogany glider habitat
Performance criterion 5.3: Grazing and fire projects complete with results informing Specific Objective 2.

Knowledge of the impacts of grazing and fire on mahogany glider habitat is required. Appropriate stocking rates or pasture management could be developed which are compatible with the maintenance of mahogany glider habitat. As this issue is complex, a robust methodology should be established to compare stocking rates, fire regimes and their relative influence on habitat and the degree of tolerance to disturbance.

Research to examine four response variables (weed invasion, rainforest encroachment, canopy recruitment, and understorey structure), replicated in each of two treatments (grazing and no grazing) with the timing of fire events held constant across the treatments would provide valuable data for decision-making. This study could be the basis for long-term monitoring of habitat variables and the measurement of fire intensity.

Potential contributors: EPA, MGSAG, research institutions, landholders, industry groups, FNQNRM.

Specific Objective 6 Ensure recovery plan is operating with high levels of community participation

Action 6.1 Promote and facilitate community involvement in mahogany glider recovery
Performance criterion 6.1: Level of community involvement and public support in mahogany glider conservation has increased over the life of the plan, shown by improved contact with landholders, increased school involvement, greater number of educational talks given and increased public inquiries.

Local communities will be encouraged and supported to participate in recovery actions. Habitat restoration, monitoring, education and other programs identified in this recovery plan should where possible involve landholders, schools and community conservation and other action groups. The development of corridor plans (Action 1.2) will be a major conduit for local community involvement. Habitat restoration programs will be integrated with regional rehabilitation strategies developed through planning mechanisms such as the Wet Tropics Conservation Strategy (WTMA 2004) and the Wet Tropics NRM Plan and Investment Strategy (FNQ NRM Ltd and Rainforest CRC 2004).

Potential contributors: EPA, WTMA, FNQNRM, local councils, community groups, Traditional Owners, local schools.

Action 6.2 Develop and disseminate a broad range of recovery plan information for stakeholders
Performance criterion 6.2: The current range of public information and educational materials reviewed and updated if required. New material for landholders, covering weed management, fencing design, grazing and fire regimes, produced and disseminated.

The mahogany glider is a high profile species and its conservation attracts much community interest and support. Complementing Action 6.1, this action will seek to raise the level of community awareness and understanding of mahogany glider conservation issues and engender positive changes in attitude and behaviour by developing and disseminating appropriate information to land managers, schools, tourists and the wider community.

A variety of mahogany glider information material has been produced over the life of the previous recovery plan. All existing material will be reviewed and evaluated as to its effectiveness and consistency of messages. If necessary, material will be updated or new material developed. Up-to-

date reference material should be collated and distributed to local libraries and other appropriate information providers as well as to DEW, EPA, WTMA and local government websites. Publicity on mahogany glider conservation and the recovery plan will continue. The Mahogany Glider Education Kit (produced by Wildlife Preservation Society of Queensland) will continue to be supported and promoted throughout schools. Educational projects promoting Aboriginal culture and mahogany glider conservation will be encouraged and supported.

A land management brochure targeting graziers and other landholders will be developed on appropriate activities to maintain mahogany glider habitat. This will include information on weed management (Action 2.4), appropriate fence design (Action 3.2) and grazing and fire regimes (Action 5.3).

Potential contributors: EPA, WTMA, FNQNRM, local councils, community groups, Traditional Owners, local schools.

Action 6.3 Promote and facilitate Aboriginal participation, capacity building and the use of traditional knowledge in mahogany glider recovery
Performance criterion 6.3: Traditional cultural knowledge of mahogany glider and habitat management documented and, where negotiated, included in recovery plan projects.

Aboriginal participation in all aspects of mahogany glider recovery can result in mutually beneficial sharing of knowledge greatly enhancing conservation of the species. Aboriginal people want to be actively involved in the management and protection of the mahogany glider and its habitat through co-management arrangements, involvement in research and monitoring of mahogany glider populations and by being involved in projects on country to rehabilitate and protect glider habitat.

Implementation of this plan will require comprehensive negotiation and consultation with Aboriginal communities to facilitate their participation. Affected Aboriginal communities will be represented on the Recovery Team and encouraged to become involved in a number of projects (e.g. mahogany glider surveys, fire management and habitat rehabilitation).

Potential contributors: EPA, WTMA, FNQNRM, Traditional Owner groups and representative bodies.

Action 6.4 Ensure recovery plan implementation is coordinated effectively
Performance criterion 6.4: Regular recovery plan meetings held with all stakeholders actively involved and supported.

Implementation of this recovery plan will be monitored and reviewed by the Recovery Team. The recovery team will establish a Mahogany Glider Scientific Advisory Group (MGSAG) comprised of specialists in relevant fields (e.g. mahogany glider scientific experts, fire management experts) to facilitate the exchange of scientific knowledge and information.

The Recovery Team should also convene workshops or similar information sharing events for stakeholder groups to facilitate the development of habitat management initiatives such as fire, grazing or weed management strategies.

Potential contributors: EPA in conjunction with Recovery Team.

Action 6.5 Review the recovery plan
Performance criterion 6.5: An independent review of the recovery plan completed in 2012.

Elements of this plan may require annual revision by the Recovery Team and will be detailed in annual reports or updates provided to the Director, Wildlife Conservation Branch, EPA. Then, as per EPBC Act requirements, the plan will be reviewed (externally) in five years to check progress of recovery and redirect any necessary actions and will be provided to DEW and EPA.

Potential contributors: EPA in conjunction with Recovery Team.

Table 3: Summary of relationship between objectives, performance criteria, actions and potential contributors.

Objectives	Performance Criteria	Actions	Potential contributors	P[a]
1: Identify and prioritise areas of mahogany glider habitat for protection, management and recovery	**1.1:** Distribution of mahogany glider habitat map reviewed, updated and made available to staff involved in management.	**1.1:** Update mahogany glider habitat mapping as required.	EPA, Mahogany Glider Scientific Advisory Group, Wet Tropics Management Authority (WTMA)	**1**
	1.2: Mahogany glider priority conservation areas identified for management action and implementation commenced.	**1.2:** Assess habitat areas for priority protection and management.	EPA, MGSAG, FNQNRM, WTMA, local councils, community groups, Traditional Owners	**2**
	1.3: Priority habitat corridors identified, assessed, mapped and action plans completed.	**1.3:** Identify and prioritise habitat corridors for protection, restoration and management.	EPA, MGSAG, WTMA, FNQNRM, local councils, community groups, Traditional Owners	**1**
	1.4: Conservation measures for private land identified, matched against priority conservation areas and strategies implemented.	**1.4:** Identify and implement strategies to conserve mahogany glider habitat on private lands.	EPA, FNQNRM, local councils, community groups, Traditional Owners	**1**
2: Improve mahogany glider habitat by managing grazing, fire and weeds	**2.1:** Habitats threatened by encroaching rainforest assessed and report prepared management practices in mahogany glider habitat and these management practices are implemented.	**2.1:** Identify and assess habitats threatened by encroaching rainforest	EPA, MGSAG, WTMA, FNQNRM, local councils, community groups	**1**
	2.2: Extension program established for landholders outlining appropriate fire, grazing and weed.	**2.2:** Engage private landholders in developing land management practices that balance mahogany glider conservation needs with other land uses.	EPA, WTMA, FNQNRM, local councils, landholders, industry groups, Traditional Owners	**2**
	2.3: Habitat recovery burns implemented at key sites.	**2.3:** Implement habitat recovery burns at key sites.	EPA, FPQ, local councils	**2**
	2.4: Existing weed management plans audited and recommendations for implementation provided to relevant authorities and landholders.	**2.4:** Improve weed control in mahogany glider habitat.	EPA, FNQNRM, local councils, landholders	**1**
3: Respond to and manage problems with easement corridors, barbed-wire fences and injured gliders	**3.1:** Guidelines to minimise mahogany glider mortality associated with transport and easement corridors incorporated into road and powerline planning, construction and maintenance.	**3.1:** Reduce threats arising from transport and easement corridors.	EPA, FNQNRM, Dept Main Roads, power authorities, local councils	**2**
	3.2: A voluntary fencing scheme to reduce glider entanglements in barbed-wire promoted and in place by 2011.	**3.2:** Promote a mahogany glider friendly fencing scheme.	EPA, FNQNRM, community groups, landholders	**3**
	3.3: A mahogany glider care, rehabilitation and release protocol prepared by 2008 and implemented as required.	**3.3:** Develop a mahogany glider care, rehabilitation and release protocol.	EPA, local wildlife care groups	**2**

4: Monitor mahogany glider populations and their habitat	**4.1:** Monitoring of mahogany glider populations and habitat in progress, at key sites that are currently actively managed.	**4.1:** Establish distributional limits of mahogany gliders, monitor populations and their habitat.	EPA, MGSAG, FNQNRM, research institutions, community groups, Traditional Owners	**2**
	4.2: Mahogany glider status re-assessed, depending on data.	**4.2:** Assess the conservation status and population size of mahogany gliders.	MGSAG, MG Recovery Team, EPA	**3**
	4.3: Mahogany glider database maintained and kept current.	**4.3:** Maintain a GIS database on mahogany gliders.	EPA	**2**
	4.4: Regular monitoring reports completed and disseminated to appropriate agencies and groups.	**4.4:** Review and report on monitoring and research outcomes.	EPA, FNQNRM	**2**
5: Improve understanding of mahogany glider ecology and threats to its survival	**5.1:** Population genetic structure and metapopulation analysis of mahogany gliders completed and a report prepared.	**5.1:** Determine the population genetic structure of mahogany gliders.	EPA, MGSAG, research institutions, FNQNRM	**3**
	5.2: Mahogany glider corridor project complete and results incorporated into corridor planning actions, including rehabilitation of priority corridors.	**5.2:** Assess the effectiveness of corridors in helping mahogany glider movement and rehabilitate priority corridors.	EPA, MGSAG, WTMA, FNQNRM, research institutions, community groups, Traditional Owners	**1**
	5.3: Grazing and fire projects complete with results informing Specific Objective 2.	**5.3:** Investigate appropriate grazing and fire regimes in mahogany glider habitat.	EPA, MGSAG, research institutions, landholders, industry groups, FNQNRM	**3**
6: Ensure recovery plan is operating with high levels of community participation	**6.1:** Level of community involvement and public support in mahogany glider conservation has increased over the life of the plan, shown by improved contact with landholders, increased school involvement, greater number of educational talks given and increased public inquiries.	**6.1:** Promote and facilitate community involvement in mahogany glider recovery.	EPA, WTMA, FNQNRM, local councils, community groups, Traditional Owners, schools	**2**
	6.2: The current range of public information and educational materials reviewed and updated if required. New material for landholders, covering weed management, fencing design, grazing and fire regimes, produced and disseminated.	**6.2:** Develop and disseminate a broad range of recovery plan information for stakeholders.	EPA, WTMA, FNQNRM, local councils, community groups, Traditional Owners, schools	**3**
	6.3: Traditional cultural knowledge of mahogany glider and habitat management documented and, where negotiated, included in recovery plan projects.	**6.3:** Promote and facilitate Aboriginal participation, capacity building and the use of traditional knowledge in mahogany glider recovery.	EPA, WTMA, FNQNRM, Traditional Owner groups and representative bodies	**1**
	6.4: Regular recovery plan meetings held with all stakeholders actively involved and supported.	**6.4:** Ensure recovery plan implementation is co-ordinated effectively.	EPA with support from the Recovery Team	**2**
	6.5: An independent review of the recovery plan completed in 2012.	**6.5:** Review the recovery plan.	EPA in conjunction with Recovery Team	**3**

a: P = Priority ranking 1 = High priority, 2 = Medium priority, 3 = Low priority

6. Management practices

A range of planning mechanisms guides mahogany glider conservation and habitat management. These include the Wet Tropics FNQ Regional Plan, Wet Tropics NRM Plan, local government planning schemes, regional coastal management plans and the Wet Tropics Conservation Strategy. Some of these have a statutory basis and may place certain constraints on development in mahogany glider habitat.

The *Vegetation Management Act 1999* (*VMA*) through the draft Regional Vegetation Management Code for Coastal Bioregions regulates and restricts clearing activities within essential mahogany glider habitat. Applications for clearing activities assessable under the *VMA* need to refer to the Code to identify the applicable Part relevant to the nature of the proposed activity, including the performance requirements for protecting essential habitat.

Essential habitat for the mahogany glider is identified by the Environmental Protection Agency, who maintains a spatial habitat database based on essential habitat factors known for the species. The distribution of essential habitat will continue to be used to assess applications to clear remnant vegetation, tenure dealings and development applications under the codes. Mapping of essential habitat will be updated regularly in line with changes to the Wet Tropics regional ecosystem mapping or with increased knowledge of the species' requirements.

Native forest harvesting on freehold properties is enforced under a code, regulated by the *VMA* and *Integrated Planning Act 1997*. Strict site access and selective felling operation controls are required, including the retention of habitat trees.

Management practice guidelines for mahogany glider habitat include such measures as:

- Utilising galvanised plain wire as the top strand for fencing.
- Retaining habitat trees, particularly those above 30cm diameter and with hollows in live trees of entrance diameter 10cm or greater. Artificial den trees may be appropriate in remnant corridors.
- Minimise disturbance on *Albizia procera*, namely through active fire and pest management.
- Avoid or minimise cattle disturbance in areas of seasonal resources, primarily in Grasstree *Xanthorrhea* pockets.
- Minimise easement width for road or railway infrastructure, or utilise where possible gliding poles across remnant corridors where easement width extends greater than 30m.

7. Evaluation of recovery plan

Progress will be monitored and evaluated annually by the recovery team. An independent external reviewer will be contracted in year four of the plan to review and evaluate performance of the recovery plan.

8. Costs of recovery

Table 4: Estimated cost of recovery ($ per year)

Action	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Total
1.1: Update mahogany glider habitat mapping as required	13,000	6000	3000	3000	3000	**28,000**
1.2: Assess habitat areas for priority protection and management	20,000	20,000	10,000	0	0	**50,000**
1.3: Identify and prioritise habitat corridors for protection, restoration and management	5000	5000	2000	0	0	**12,000**
1.4: Identify and implement strategies to conserve mahogany glider habitat on private lands	10,000	10,000	5000	0	0	**25,000**
2.1: Identify and assess habitats threatened by encroaching rainforest	5000	20,000	10,000	5000	5000	**45,000**
2.2: Engage private landholders in developing land management practices that balance mahogany glider conservation needs with other land uses	10,000	15,000	10,000	10,000	5000	**50,000**
2.3: Implement habitat recovery burns at key sites	15,000	15,000	15,000	15,000	15,000	**75,000**
2.4: Improve weed control in mahogany glider habitat	5000	5000	5000	5000	5000	**25,000**
3.1: Reduce threats arising from transport and easement corridors	2000	2000	10000	2000	2000	**18,000**
3.2: Promote a mahogany glider friendly fencing scheme	2000	5000	5000	2000	2000	**16,000**
3.3: Develop a mahogany glider care, rehabilitation and release protocol.	3000	1000	1000	1000	1000	**7000**
4.1: Establish distributional limits of mahogany gliders, monitor populations and their habitat	10,000	10,000	10,000	10,000	10,000	**50,000**
4.2: Assess the conservation status and population size of mahogany gliders	0	0	0	2000	4000	**6000**
4.3: Maintain a GIS database on mahogany gliders	1000	1000	1000	1000	1000	**5000**
4.4: Review and report on monitoring and research outcomes	1000	1000	1000	5000	5000	**13,000**
5.1: Determine the population genetic structure of mahogany gliders	10,000	10,000	5000	2000	2000	**29,000**
5.2: Assess the effectiveness of corridors in helping mahogany glider movement	0	5000	20,000	20,000	20,000	**65,000**
5.3: Investigate appropriate grazing and fire regimes in mahogany glider habitat	5000	10,000	10,000	10,000	3000	**38,000**
6.1: Promote and facilitate community involvement in mahogany glider recovery	3000	3000	3000	3000	3000	**15,000**
6.2: Develop and disseminate a broad range of recovery plan information for stakeholders	2000	2000	5000	5000	5000	**19,000**
6.3: Promote and facilitate Aboriginal participation, capacity building and the use of traditional knowledge in mahogany glider recovery	5000	5000	5000	5000	5000	**25,000**
6.4: Ensure recovery plan implementation is co-ordinated effectively	3000	3000	3000	3000	3000	**15,000**
6.5: Review the recovery plan	0	0	0	0	5000	**5000**
TOTAL	**130,000**	**154,000**	**139,000**	**107,000**	**100,000**	**636,000**

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Appendix 1. Recovery team membership

Individuals from the following groups are members of the recovery team and contributed to the preparation of this recovery plan.

Environmental Protection Agency (EPA)
Forest Plantations Queensland (FPQ)
Department Natural Resources and Water (DNRW)
Hinchinbrook Shire
Cardwell Shire
AgForce
Wildlife Preservation Society of Qld (WPSQ)
Cardwell and District Banana Growers
Canegrowers Herbert
Far North Queensland NRM Ltd
Girringun Aboriginal Corporation
Mahogany Glider Scientific Advisory Group (MGSAG)