Australian Government

Draft National Recovery Plan for the

Grey-headed Flying-fox *Pteropus poliocephalus*

V. Jones

July 2009

Queensland Government Environmental Protection Agency

Department of Environment, Climate Change and Water NSW

State Government Victoria Department of Sustainability and Environment

Prepared by Dr Peggy Eby and by the Department of Environment, Climate Change and Water NSW for the Australian Government Department of the Environment, Water, Heritage and the Arts.

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Department of Environment, Climate Change and Water NSW
59–61 Goulburn Street, Sydney
PO Box A290, Sydney South NSW 1232
Ph: (02) 9995 5000 (switchboard)
Ph: 131 555 (environment information and publications requests)
Fax: (02) 9995 5999
TTY: (02) 9211 4723
Email: info@environment.nsw.gov.au
Website: www.environment.nsw.gov.au

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Acknowledgments

This recovery plan sets out the actions necessary to stop the decline of, and support the recovery of, the listed threatened species or ecological community. The Australian Government is committed to acting in accordance with the plan and to implementing the plan as it applies to Commonwealth areas.

This recovery plan has been prepared under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and structured according to the *Revised Recovery Plan Guidelines for Nationally Listed Threatened Species and Ecological Communities*, June 2002.

The plan has been developed with the involvement and cooperation of a broad range of stakeholders, but individual stakeholders have not necessarily committed to undertaking specific actions. The attainment of objectives and the provision of funds may be subject to budgetary and other constraints affecting the parties involved. Proposed actions may be subject to modification over the life of the plan owing to changes in knowledge.

This plan benefited substantially from the diligence of members of the National Recovery Team. Members were actively involved in developing content and providing critical input to each section of the recovery plan. They approached the project with consistent cooperation and goodwill. Peggy Eby, Kylie McClelland, Lindy Lumsden and Bruce Thomson participated in the early stages of planning the project. Thanks to Peter Fleming of the NSW Department of Primary Industries. Many others also contributed to, and commented on, drafts of this recovery plan, as members of email discussion groups or as interested individuals. Their involvement and input improved the quality of the document. Unfortunately, they are too numerous to list by name. State and Territory Government representatives Andrew Chalklen, Adrian Moorrees, Linda Bell and Sara Williams are thanked for their roles in the finalisation of this draft recovery plan.

Kylie McClelland of the Department of Environment, Climate Change and Water NSW collated final comments and edits and prepared the final draft.

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National Recovery Team

A National Recovery Team was convened to provide advice and expertise. The recovery team was structured to be representative of the many and varied stakeholders who have interests in the conservation and management of Grey-headed Flying-foxes and to be representative of the regions within the geographic range of the species. The following people participated, and they brought to the process a breadth of personal experience with Grey-headed Flying-foxes.

Amanda Lawrence	Species Listing and Policy Section, Approvals and Wildlife Division, Department of the Environment and Heritage (now the Department of the Environment, Water, Heritage and the Arts)
Kylie McClelland	Biodiversity Conservation Unit, Department of Environment, Climate Change and Water NSW
Lindy Lumsden	Arthur Rylah Institute, Victoria Department of Sustainability and Environment
David Dique	(formerly) Environmental Protection Agency (Qld)
Craig Walker	Environmental Protection Agency (Qld)
Ed Biel	NSW Farmers' Association
Jane Muller	Natural Resource Management, Growcom (Queensland)
Nicola Markus	(formerly) Species and Community Program Manager, WWF Australia
Nancy Pallin	NSW Nature Conservation Council
Robert James	Flying-fox Information and Conservation Network
Martin Smith	Ranger, Coffs Coast Area, Department of Environment, Climate Change and Water NSW
Ian Temby	Wildlife Damage Control Officer, Port Phillip Region, Victoria Department of Sustainability and Environment
Simon Toop	Grey-headed Flying-fox (former) Project Manager, Biodiversity and Natural Resources, Victoria Department of Sustainability and Environment
Peggy Eby	Consultant wildlife ecologist
John Nelson	Biological Sciences, Monash University
Kerryn Parry-Jones	Institute of Wildlife Research, School of Biological Sciences, University of Sydney
Mark Graham	(formerly) Terrestrial Ecologist, Coffs Harbour City Council
Kevin Taylor	(formerly) Natural Resources Officer, Coffs Harbour City Council
Greg Lollback	Resource Access Manager, former Department of Natural Resources NSW (now the Department of Environment, Climate Change and Water NSW)

Executive summary

This document constitutes the Draft National Recovery Plan for the Grey-headed Flying-fox *Pteropus poliocephalus.* It considers the conservation requirements of the species throughout its range, sets objectives for recovery and identifies actions to be undertaken to reverse decline and ensure long-term viability.

The Grey-headed Flying-fox is listed as Vulnerable under both the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and the New South Wales *Threatened Species Conservation Act 1995*. The species is listed as threatened under the Victorian *Flora and Fauna Guarantee Act 1988*, and its threatened status is under consideration in Queensland. The primary threats affecting the species are loss and degradation of foraging and roosting habitat, deliberate destruction associated with commercial horticulture and competition for resources from the Black Flying-fox, *Pteropus alecto.*

Grey-headed Flying-foxes occupy forests and woodlands in the coastal lowlands, tablelands and slopes of southeast Australia from Bundaberg to Geelong. They are migratory bats that are primarily found in coastal areas. Few localities support a continuous presence. Rare sightings occur north to Gladstone, west to Adelaide, south to Flinders Island and in inland areas of southern New South Wales and Victoria.

Grey-headed Flying-foxes feed on blossom and fruit in canopy vegetation and forage over extensive areas. They disperse pollen and seeds of diet plants during their foraging bouts; in this way they participate in the reproductive and evolutionary processes of forest communities. Clearing of native vegetation continues to reduce food production from native plants in the flying-foxes' diet, and food shortages are known to occur in winter and in spring. When native food is scarce, individuals increase their use of cultivated plants, particularly commercial fruit crops, exposing them to mortality from crop management practices.

The species is colonial and roosts in large aggregations in the exposed branches of canopy trees (camps). When the camps are undisturbed their locations are generally stable through time. Camp size fluctuates, and many camps are empty for extensive periods. Conflict between humans and flying-foxes is an ongoing and apparently increasing problem, particularly affecting camps located near human development. Conflict and negative perceptions of Grey-headed Flying-foxes can affect the species directly through harassment and deliberate destruction, or indirectly by inhibiting or impeding community support for conservation initiatives.

The overall objectives of recovery of Grey-headed Flying-foxes are: to reduce the impact of threatening processes; to arrest decline throughout their range; to conserve their functional roles in seed dispersal and pollination of native plants; and to improve the comprehensiveness and reliability of information available to guide recovery.

Specific objectives relevant to the 5-year duration of this recovery plan aim to identify, protect and enhance key foraging and roosting habitat; to substantially reduce deliberate destruction associated with commercial fruit crops; to reduce negative public attitudes and conflict with humans; and to involve the community in recovery actions where appropriate. Further objectives aim to address the impact on the species of artificial structures such as powerlines, loose netting and barbed wire fences; and to improve knowledge of demographics and population structure.

Actions to meet these objectives incorporate principles of sustainable development and promote procedures to minimise significant adverse social and economic impacts, such as the use of environmental incentive schemes and equitable cost-sharing arrangements.

1 Species information and general requirements

1.1 Species identification

The Grey-headed Flying-fox *Pteropus poliocephalus* Temminck 1825 is one of the largest bats in the world. Adult males generally weigh between 750 and 1000 g, and weights as high as 1133 g have been recorded (Ratcliffe 1932, Tidemann 1995, J. Nelson, Monash University unpublished data). Adult females generally weigh between 650 and 800 g. Although males and females differ in weight, their forearms are of similar length at 155 to 175 mm. Body fur is typically medium to dark grey, with many light-tipped hairs (Hall and Richards 2000). Fur on the head is also grey but varies in shade from near black to silver. An orange or russet-coloured mantle or collar encircles the neck. Leg fur extends to the ankle, and this characteristic distinguishes the species from the similarly sized Black Flying-fox, *P. alecto*, the legs of which are bare below the knee. Wing membranes are black.

1.2 Conservation status

Since the time of European settlement of Australia Grey-headed Flying-foxes have been subjected to ongoing loss of foraging habitat; direct, deliberate destruction in commercial fruit crops and in diurnal roosts (camps); and competition with Black Flying-foxes for resources (Ratcliffe 1931, Tidemann *et al*. 1999). These and other threatening processes have resulted in an ongoing decline in abundance. Ratcliffe (1932) hypothesised that a 50% reduction in abundance had occurred by the late 1920s. There is evidence of a decline of approximately 30% since 1989 (Tidemann *et al.* 1999, Parry-Jones 2000, Threatened Species Scientific Committee 2001). For these reasons, the Grey-headed Flying-fox is listed as Vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the New South Wales *Threatened Species Conservation Act 1995* and as threatened under the Victorian *Flora and Fauna Guarantee Act 1988.* Its threatened status in Queensland is under consideration.

1.3 Taxonomy

The taxonomy of the Grey-headed Flying-fox is considered unambiguous (Tidemann 1995, Webb and Tidemann 1996). No intraspecific taxa are recognised.

1.4 Objects of the EPBC Act

This recovery plan has been prepared with due consideration of the objects of the EPBC Act, which are:

(a) to provide for the protection of the environment, especially those aspects of the environment that are matters of national environmental significance
(b) to promote ecologically sustainable development through the conservation and ecologically sustainable use of natural resources
(c) to promote the conservation of biodiversity
(d) to promote a co-operative approach to the protection and management of the environment involving governments, the community, land-holders and indigenous peoples
(e) to assist in the co-operative implementation of Australia's international environmental responsibilities
(f) to recognise the role of indigenous people in the conservation and ecologically sustainable use of Australia's biodiversity
(g) to promote the use of indigenous peoples' knowledge of biodiversity with the involvement of, and in co-operation with, the owners of the knowledge.

1.5 International obligations

The Grey-headed Flying-fox is endemic to Australia and is not listed under any international agreements.

1.6 Affected interests

A wide range of public authorities, organisations and private individuals may be affected by actions to recover the Grey-headed Flying-fox. The habitats used by the species for foraging and roosting are varied and widespread. They include intact and remnant native forests and woodlands, paddock trees in agricultural landscapes, garden and streetscape plantings in urban areas and cultivated fruit trees. Management of foraging and roosting habitat falls under the jurisdiction of a range of authorities and is regulated by Commonwealth and State legislation in the three range States of the species, as well as by the policies of local government areas throughout the range of the species.

Government agencies with affected interests include:

Australian Government

Department of the Environment, Water, Heritage and the Arts

Queensland Government

Environmental Protection Agency
Department of Primary Industry and Fisheries
Department of Natural Resources and Water
Department of Local Government, Sport and Recreation

New South Wales Government

Department of Environment, Climate Change and Water (including National Parks and Wildlife Service),
Royal Botanic Gardens Trust
Department of Planning
Department of Primary Industries (including NSW Agriculture, Forests NSW)

Victorian Government

Department of Sustainability and Environment
Department of Primary Industries
Parks Victoria

Local Government

Local government areas throughout the range of the species

State-based resource management groups

Queensland – Natural Resource Management groups
New South Wales – Catchment Management Authorities
Victoria – Catchment Management Authorities

Actions proposed as part of this recovery plan may affect various members of the community, including:

- private landholders whose properties provide foraging or roosting habitat
- persons whose homes immediately adjoin camps
- conservation organisations
- licensed animal rehabilitators and their representative organisations
- individuals and groups involved in tree-planting and habitat restoration programs
- volunteers involved in flying-fox surveys and population estimates

- individual researchers and their representative organisations.

Proposed actions may also affect individual commercial fruit growers and representative organisations, including:

- BananasNSW
- NSW Farmers' Association
- Queensland – Growcom (formerly Queensland Fruit and Vegetable Growers)
- Victoria – Eastern Metropolitan Fruit Growers Association.

1.7 Role and interests of indigenous people

In making a recovery plan, regard must be given to the role and interests of indigenous people in the conservation of Australia's biodiversity. The indigenous communities in regions affected by this plan have not yet been identified. Implementation of recovery actions under this plan will include consideration of the roles and interests of indigenous communities.

There will be further indigenous consultation before finalisation of the plan. In Queensland, consultation will occur via the Indigenous Liaison Officers of the relevant Natural Resource Management Groups. In New South Wales, consultation will occur through Department of Environment, Climate Change and Water contact with interested Aboriginal Land Councils and Catchment Management Authorities, Aboriginal Reference Groups and through direct contact with indigenous organisations. In Victoria, indigenous communities on whose traditional lands the Grey-headed Flying-fox occurs will be advised, through the relevant Department of Sustainability and Environment Regional Indigenous Facilitator, of the preparation of this draft Recovery Plan and invited to provide comments. The public exhibition phase provides an opportunity for indigenous people to comment on the draft recovery plan.

1.8 Benefits to other species

Management actions to recover the Grey-headed Flying-fox will provide direct benefits to various species of fauna and flora, including several species listed as threatened under State and Commonwealth legislation (Table 1). They will also benefit various threatened plant communities and three of Australia's World Heritage Areas: Fraser Island, the Central Eastern Rainforest Reserves and the Greater Blue Mountains.

Grey-headed Flying-foxes interact with numerous plant communities and confer the benefits of seed and pollen dispersal on the diet plants that occur within these communities (Eby 1996, Southerton *et al.* 2004, Birt 2005). Actions to arrest the decline in the Grey-headed Flying-fox population will protect these important ecosystem functions. Diet lists for Grey-headed Flying-foxes include over 100 species of flowering trees and fleshy-fruited trees and lianas (Parry-Jones and Augee 1991, Eby 1995 and 1998, Hall and Richards 2000). Actions to protect or regenerate foraging and roosting habitat will benefit several hundred vegetation communities in Queensland, New South Wales and Victoria (P. Eby and B. Law unpublished data). Nectar- and fruit-feeding bats, birds and mammals will also benefit, as will a range of other fauna that occupy the forest and woodland communities used by Grey-headed Flying-foxes.

Actions to protect roosting habitat and ameliorate conflict at camps in urban areas will additionally benefit the Black Flying-foxes and Little Red Flying-foxes that share communal camps with Grey-headed Flying-foxes (Birt and Markus 1999, Tidemann 1999, Eby 2004).

Actions to reduce deliberate destruction associated with commercial fruit crops by introducing alternative crop management techniques will benefit other native vertebrates that damage crops, including Black Flying-foxes, Little Red Flying-foxes, and several species of birds, including Little and Long-billed Corellas, Galahs, Pied Currawongs, Red Wattlebirds, Noisy Friarbirds, Black-faced Cuckoo-shrikes, Musk Lorikeets, Rainbow Lorikeets, Scaly-breasted Lorikeets, Crimson Rosellas, Eastern Rosellas, Pale-headed Rosellas, Australian King-Parrots, Silvereyes, Satin Bowerbirds, Yellow-faced and Blue-faced Honeyeaters, Figbirds and Olive-backed Orioles (Bomford and Sinclair 2002).

Implementation of this recovery plan is not expected to adversely impact other species or ecological communities.

Table 1: Species and communities that are listed under Commonwealth and State threatened species legislation and will benefit from actions to recover the Grey-headed Flying-fox

CE = listed as critically endangered, E = listed as endangered, V = listed as vulnerable, T = listed as threatened, R = listed as rare. The fauna on this list is limited to birds and mammals.

Species, population or community	Aust Govt	Qld	NSW	Vic
Flora				
Species and populations				
Eucalyptus seeana population at Taree			E	
E. parramattensis decadens	V		V	
E. parramattensis parramattensis population at Wyong and Lake Macquarie			E	
Davidsonia spp.	E		E	
Eucalyptus tetrapleura	V		V	
Syzygium paniculatum	V		V	
Vegetation communities				
Bangalay Sand Forest, Sydney Basin and South East Corner Bioregions			E	
Bega Dry Grass Forest South East Corner Bioregion			E	
Blue Gum High Forest Sydney Basin Bioregion	CE		CE	
Brogo Wet Vine Forest South East Corner Bioregion			E	
Candelo Dry Grass Forest South East Corner Bioregion			E	
Castlereagh Swamp Woodland			E	
Casuarina glauca open forest		E		
Central Gippsland Plains Grassland				T
Corymbia citriodora open forest		E		
Cumberland Plain Woodland	E		E	
Dry Rainforest of the South East Forests of the South East Corner Bioregion			E	
Eastern Suburbs Banksia Scrub Sydney Basin Bioregion	E		E	
Eucalyptus camaldulensis fringing open forest		E		
Eucalyptus camaldulensis in the Hunter Catchment			E	
Eucalyptus melanophloia, E. crebra woodland on sedimentary rocks		E		
Eucalyptus melliodora woodland		E		
Eucalyptus moluccana open forest		E		
Eucalyptus populnea woodland on alluvial plains		E		
Eucalyptus seeana, Corymbia intermedia, Angophora leiocarpa woodland		E		
Eucalyptus siderophloia, E. propinqua, E. microcorys and/or *E. pilularis* tall open forest		E		
Eucalyptus tereticornis, Angophora floribunda open forest on alluvial plains		E		
Eucalyptus tereticornis, Corymbia intermedia on remnant Tertiary surfaces		E		
Eucalyptus tereticornis woodland to open forest on alluvial plains		E		
Eucalyptus tindaliae and/or *E. racemosa* open forest		E		
Forest Red Gum Grassy Woodland				T
Gallery rainforest (notophyll vine forest) alluvial plains		E		
Grassy White Box Woodlands	E			
Herb-rich Plains Grassy Wetland (West Gippsland)				T

Table 1 cont'd: Species and communities that are listed under Commonwealth and State threatened species legislation and will benefit from actions to recover the Grey-headed Flying-fox

CE = listed as critically endangered, E = listed as endangered, V = listed as vulnerable, T = listed as threatened, R = listed as rare. The fauna on this list is limited to birds and mammals.

Species, population or community	Aust Govt	Qld	NSW	Vic
Illawarra Lowlands Grassy Woodland in the Sydney Basin Bioregion			E	
Illawarra Subtropical Rainforest Sydney Basin Bioregion			E	
Limestone Grassy Woodland Community				T
Littoral Rainforest NSW North Coast, Sydney Basin and South East Corner Bioregions			E	
Lower Hunter Spotted Gum – Ironbark Forest in the Sydney Basin Bioregion			E	
Lowland Grassy Woodland in the South East Corner Bioregion			E	
Lowland Rainforest in the NSW South Coast and Sydney Basin Bioregions			E	
Melaleuca irbyana low open forest		E		
Microphyll/notophyll vine forest on beach ridges		E		
Milton Ulladulla Subtropical Rainforest in the Sydney Basin Bioregion			E	
River-Flat Eucalypt Forest on Coastal Floodplains of NSW North Coast, Sydney Basin and South East Corner Bioregions			E	
O'Hares Creek Shale Forest			E	
Pittwater Spotted Gum Forest			E	
Shale Gravel Transition Forest Sydney Basin Bioregion	E		E	
Shale/ Sandstone Transition Forest			E	
Southern Sydney Sheltered Forest on Transitional Sandstone Soils in the Sydney Basin Bioregion			E	
Subtropical Coastal Floodplain Forest NSW North Coast Bioregion			E	
Sun Valley Cabbage Gum Forest Sydney Basin Bioregion			E	
Swamp Oak Floodplain Forest NSW North Coast, Sydney Basin and South East Corner Bioregions			E	
Swamp Sclerophyll Forest on Coastal Floodplains of NSW North Coast, Sydney Basin and South East Corner Bioregions			E	
Sydney Turpentine-Ironbark Forest	CE		E	
Syncarpia glomulifera open forest		E		
Tall open forest of *Eucalyptus pilularis*		E		
Tall open forest with *Eucalyptus cloeziana*		E		
Umina Coastal Sandplain Woodland in the Sydney Basin Bioregion			E	
Warm Temperate Rainforest (Coastal East Gippsland)				T
Warm Temperate Rainforest (East Gippsland Alluvial Terraces)				T
Warm Temperate Rainforest (Far East Gippsland)				T
White Box Yellow Box Blakely's Red Gum Woodland	CE		E	

Table 1 cont'd: Species and communities that are listed under Commonwealth and State threatened species legislation and will benefit from actions to recover the Grey-headed Flying-fox

CE = listed as critically endangered, E = listed as endangered, V = listed as vulnerable, T = listed as threatened, R = listed as rare. The fauna on this list is limited to birds and mammals.

Species, population or community	Aust Govt	Qld	NSW	Vic
Fauna (birds and mammals only)				
Birds				
Albert's Lyrebird			V	
Barking Owl			V	T
Barred Cuckooshrike			V	
Black-breasted Button Quail	V	V	E	
Black-chinned Honeyeater		R	V	
Brown Treecreeper (eastern sub-species)			V	
Bush Hen			V	
Coxen's Fig Parrot	E	E	E	
Emu population of the NSW North Coast Bioregion and Port Stephens Local Government Area			E	
Gang-gang Cockatoo			V	
Gang-gang Cockatoo in the Hornsby and Ku-ring-gai Local Government Areas			E	
Hooded Robin (south-eastern form)			V	T
Mangrove Honeyeater			V	
Marbled Frogmouth		V	V	
Masked Owl			V	T
Powerful Owl		V	V	T
Purple-crowned Lorikeet			V	
Regent Honeyeater	E	E	E	T
Rose-Crowned Fruit-dove			V	
Rufous Scrub-bird		V	V	
Sooty Owl			V	
Superb Fruit-dove			V	
Swift Parrot	E	E	E	T
Turquoise Parrot			V	T
White-eared Monarch			V	
Wompoo Fruit-dove			V	
Mammals				
Brush-tailed Phascogale			V	T
Eastern Pygmy Possum			V	
Greater Glider in the Eurobodalla Local Government Area			E	
Koala		V	V	
Koala population in the Hawks Nest and Tea Gardens area			E	
Koala population in the Pittwater Local Government Area			E	
Koala population South East Queensland Bioregion		V		
Long-nosed Potoroo	V	V	V	T
Long-nosed Potoroo population Cobaki Lakes and Tweed Heads West			E	
Long-footed Potoroo	E		E	T
Parma Wallaby			V	
Red-legged Pademelon			V	
Rufous Bettong			V	T
Southern Brown Bandicoot	E		E	
Spotted-tail Quoll		V	V	T
Squirrel Glider			V	T
Squirrel Glider population on the Barrenjoey Peninsula			E	
White-footed Dunnart			V	T
Yellow-bellied Glider			V	

This recovery plan encompasses a range of broad biodiversity and conservation issues and principles, many of which have been identified as significant to Australia (Williams *et al*. 2001). Examples include maintenance of functional ecosystems; preservation of connectivity across landscapes and regions; involvement of private landholders in biodiversity conservation; equitable cost-sharing for biodiversity conservation; land clearing; forest degradation; sustainable management practice; targeted habitat restoration; human population growth in coastal areas; urban habitat as refuge; conflict between humans and wildlife; and, importantly, the need to actively educate and involve the public in conservation and biodiversity initiatives.

1.9 Social and economic impacts

The implementation of this recovery plan will be associated with various social and economic costs and benefits. Many initiatives for habitat preservation will affect privately owned land with commercial value. Management actions may restrict, or result in additional costs to, residential development, agricultural expansion and commercial forestry practice. Initiatives to reduce deliberate destruction of flying-foxes on crops will require shifts in management practices; these shifts might result in substantial costs to commercial fruit industries.

There are few non-lethal alternatives available to industry, and their effectiveness remains a topic of debate. Similarly to deliberate destruction, deterrents that involve sight, sound and smell are generally believed to provide a degree of protection when pressure from flying-foxes is low, but they have been found to be ineffective when pressure is high (Bicknell 2002, Teagle 2002, Ballard 2004).

The only method of crop protection that is unambiguously effective is the provision of complete physical barriers, such as full exclusion netting or reinforced banana bags. Rates of uptake in some regions have increased in recent years in response to rising levels of damage by flying-foxes and birds (P. Wilks pers. comm., NSW Agriculture). Netting requires a substantial capital outlay, and concerns have been raised regarding the impact of installing netting on the economic viability of individual orchards (Gough 2002, Ullio 2002). Economic models have shown that netting provides a viable protection option for some crops (Rigden *et al.* 2000); growers generally consider it appropriate for crops of relatively high value that are cultivated on relatively flat land and can be pruned to an appropriate height. However, netting is not a financially viable management option on several previously viable crops, such as various stone and pome fruit crops in the Sydney Basin region (Ullio 2002). Measures are needed to increase rates of netting uptake on these problematic crops, or otherwise to encourage the use of non-lethal management methods. People living adjacent to orchards also raise safety concerns in relation to shooting at night. This issue is becoming more prevalent as human population densities in rural and semi-rural areas increase.

The incidence of crop visitation by Grey-headed Flying-foxes is not declining in line with the decline in the population of this species. Instead, crop damage is reportedly increasing, particularly in the southern half of the range, and this trend is likely to continue (Biel 2002, Comensoli 2002, Rogers 2002, I. Temby pers. comm., Victorian Department of Sustainability and Environment). If flying-foxes increase their use of crops when native food is limited, one would predict that the fruit industry in eastern Australia will experience difficulties with flying-foxes so long as the bats experience periods of inadequate food. Food shortages are likely to persist into the future as a consequence of ongoing forest loss. This loss of habitat is not being caused by commercial fruit operations. There is general concern within the industry that growers should not be financially disadvantaged by the resulting change to the status of Grey-headed Flying-foxes, a change that may preclude the use of deliberate destruction (Biel 2002).

Comprehensive implementation of this recovery plan will provide long-term economic benefits associated with the protection of ecosystem services, promotion of sustainable forest management, reduced conflict at camps, improved crop protection regimes, promotion of sustainable agricultural practices and increased viability of some commercial fruit industries. Programs to preserve continuous nectar production from diet plants will benefit the apiary

industry. Programs to conserve and enhance foraging habitat that is productive at times critical for the commercial fruit industry will reduce impacts on crops (Law *et al.* 2002).

Social benefits from this recovery plan will be derived from reduced conflict between humans and flying-foxes, particularly at camps and in crops; a public better informed about flying-foxes and broader conservation issues; and increased public participation in conservation initiatives. The camps and the dusk exit flights of Grey-headed Flying-foxes are increasingly being recognised as attractions for eco-tourism, as is apparent at camps in Grafton, Wingham, Bellingen and Yarra Bend. Programs to protect camps and ameliorate conflict with neighbours will benefit tourism in urban and regional areas. Initiatives to promote equity in the cost of biodiversity conservation will provide positive social and economic outcomes (Biel 2002).

2 Distribution and location

Grey-headed Flying-foxes occupy the coastal lowlands and slopes of southeastern Australia from Bundaberg to Geelong and are usually found at altitudes < 200 m (Figure 1). Areas of repeated occupation extend inland to the tablelands and western slopes in northern New South Wales and the tablelands in southern Queensland. Sightings in inland areas of southern New South Wales and Victoria are uncommon. There are rare records of individuals or small groups west to Adelaide, north to Gladstone and south to Flinders Island.

2.1 Seasonal patterns of distribution

The Grey-headed Flying-fox is a highly mobile, migratory species that relies on food sources with largely irregular patterns of production (Law *et al*. 2000). Patterns of occurrence and relative abundance within its distribution vary widely between seasons and between years. When assessed at a local scale, the species is generally present intermittently and irregularly (Eby and Lunney 2002). However, broad trends in the distribution of plants with similar flowering and fruiting schedules support regular annual cycles of migration that are apparent at regional scales (Eby and Lunney 2002, Figure 2). The metropolitan areas of Brisbane, Newcastle, Sydney and Melbourne are occupied continuously (Pallin 2000, Hall 2002, van der Ree *et al.* 2006). Elsewhere, during spring Grey-headed Flying-foxes are uncommon south of Nowra and widespread in other areas of their range. They are widespread throughout their range in summer. In autumn, they occupy coastal lowlands and are uncommon inland. In winter they congregate in coastal lowlands north of the Hunter Valley and are occasionally found on the south coast of New South Wales (associated with flowering Spotted Gum *Corymbia maculata*) and the northwest slopes (generally associated with flowering White Box *Eucalyptus albens* or Mugga Ironbark *E. sideroxylon*).

2.2 Historical change to distribution

There is evidence that the northern limit to the range of Grey-headed Flying-foxes has contracted by approximately 500 km during the past 100 years. Collett (1887) recorded large numbers of the species in Mackay. Fifty years later, Ratcliffe (1931) identified Rockhampton as the northern limit to their range. The current limit is 250 km farther south. There is no evidence that the southern limit to distribution has changed. Grey-headed Flying-foxes were first recorded in Melbourne and Geelong in the mid-1880s and were recorded as far west as Warrnambool in the early 1960s (Nelson 1965a, Victorian Department of Sustainability and Environment 2005). Insufficient information exists to enable the assessment of change to inland boundaries.

Patterns of occupancy and abundance have altered in some parts of the range. During the past 20 years the numbers of animals occupying camps in metropolitan Newcastle, inner Sydney and Melbourne/Geelong have increased, and several camps in these large urban areas have changed their patterns of occupation from seasonal use to continuous use (Richards 2002, van der Ree *et al.* 2006, D. Bidwell Royal Botanic Gardens Sydney unpublished). The increasing occurrence in Melbourne has resulted in a general increase in sightings in Gippsland and on the south coast of New South Wales as animals migrate to and from Melbourne (Tidemann and Nelson 2004).

2.3 Extent and geographical locations of populations

Grey-headed Flying-foxes are partial migrants: some individuals migrate whereas others are sedentary (Fleming and Eby 2003, Tidemann and Nelson 2004). A small number of local areas support a continuous presence and others are associated with regular, annual patterns of use (Figure 3). There is consistent evidence from radio-telemetry, satellite-telemetry and banding studies that these patterns of camp occupation reflect behavioural subdivisions in the population, including resident animals that inhabit camps permanently and individuals with seasonal fidelity to specific camps (Eby 1991, Parry-Jones and Augee 2001, Fleming and Eby

2003, Tidemann and Nelson 2004). There is no evidence that these behaviours are expressed in the genetic structure of the species, although the question has not been specifically addressed by research (Webb and Tidemann 1996). Resident populations occur in urban centres in southeast Queensland, Newcastle, Sydney and Melbourne, where highly diverse garden and streetscape plantings, including exotic plants and weeds, provide a continuous source of food, as well as vegetation suitable for roosting (Parry-Jones and Augee 2001, Hall 2002, Birt 2005, van der Ree *et al.* 2006). In addition, the natural diversity of food plants in a number of coastal areas of the Interim Biogeographic Regionalisation of Australia bioregions of southeast Queensland and the New South Wales north coast supports a continuous presence (Eby 1995, 1996). Camps with annual patterns of occupation occur in coastal areas and are common north from Batemans Bay, New South Wales.

Figure 1. Distribution of Grey-headed Flying-foxes, showing sightings recorded since 1984
There are few data from inland regions, and blank localities on the map cannot be interpreted as areas never occupied by the species.

- ● = records from areas of repeated occupation (> 1 record in a 40 km radius)
- ◉ = areas of unusual occupation (one record in a 40 km radius)
- ○ = vagrants (records of individuals or small groups in unusual areas)

(Sources: Atlas of NSW Wildlife, NSW DEC 2004; Atlas of Victorian Wildlife, Victoria DSE 2004; WildNet, QPWS 2004; Eby 2004; Tidemann and Nelson 2004; G. O'Brien, University of New England unpublished data; T. Reardon, South Australian Museum unpublished data.)

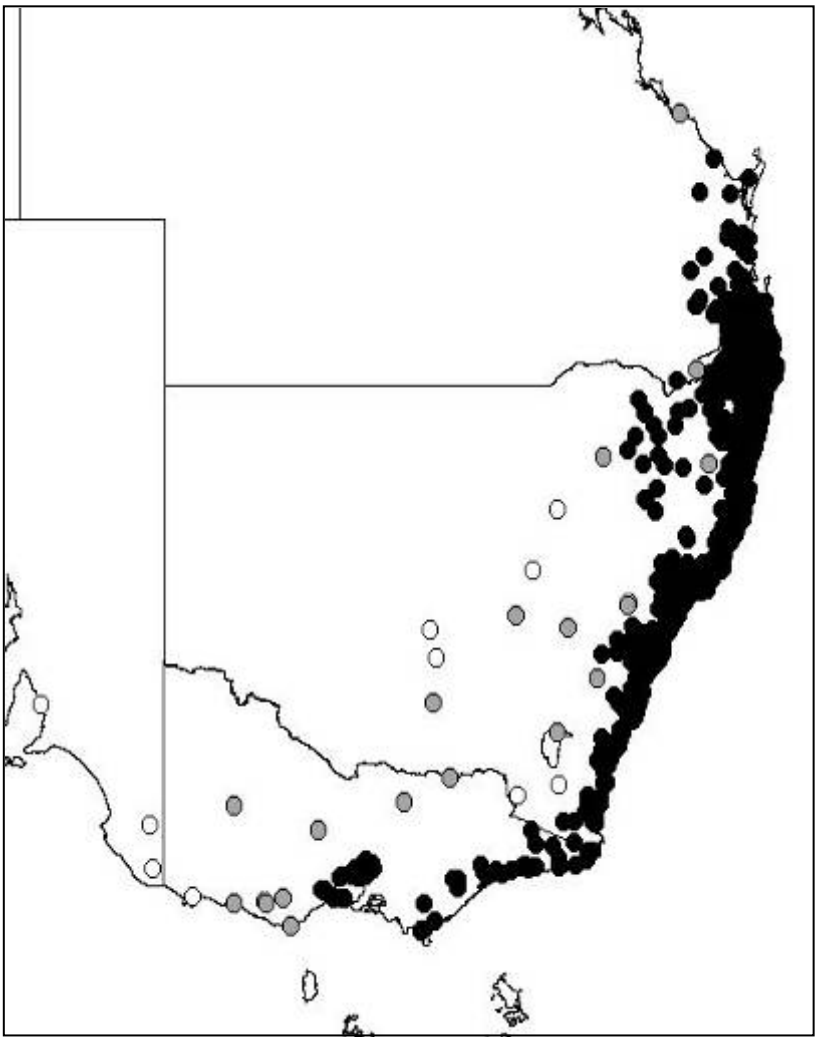


Figure 2: Seasonal sightings of Grey-headed Flying-foxes in areas of repeated occupation, as described in Figure 1

Winter sightings associated with the urban areas of Sydney and Melbourne are outlined to differentiate them from sightings in non-urban areas and highlight the importance of native vegetation in the northern half of the range in that season.

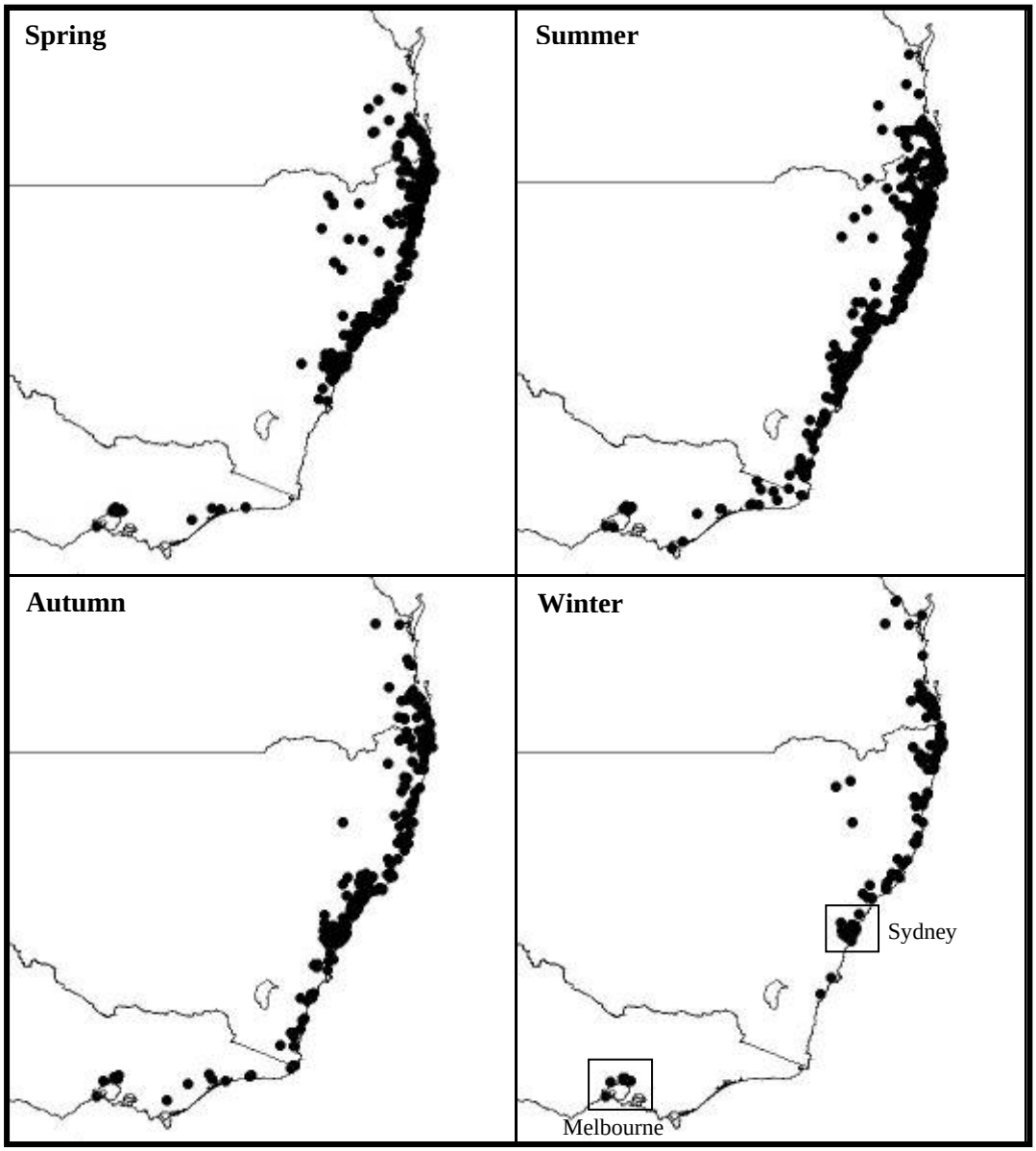
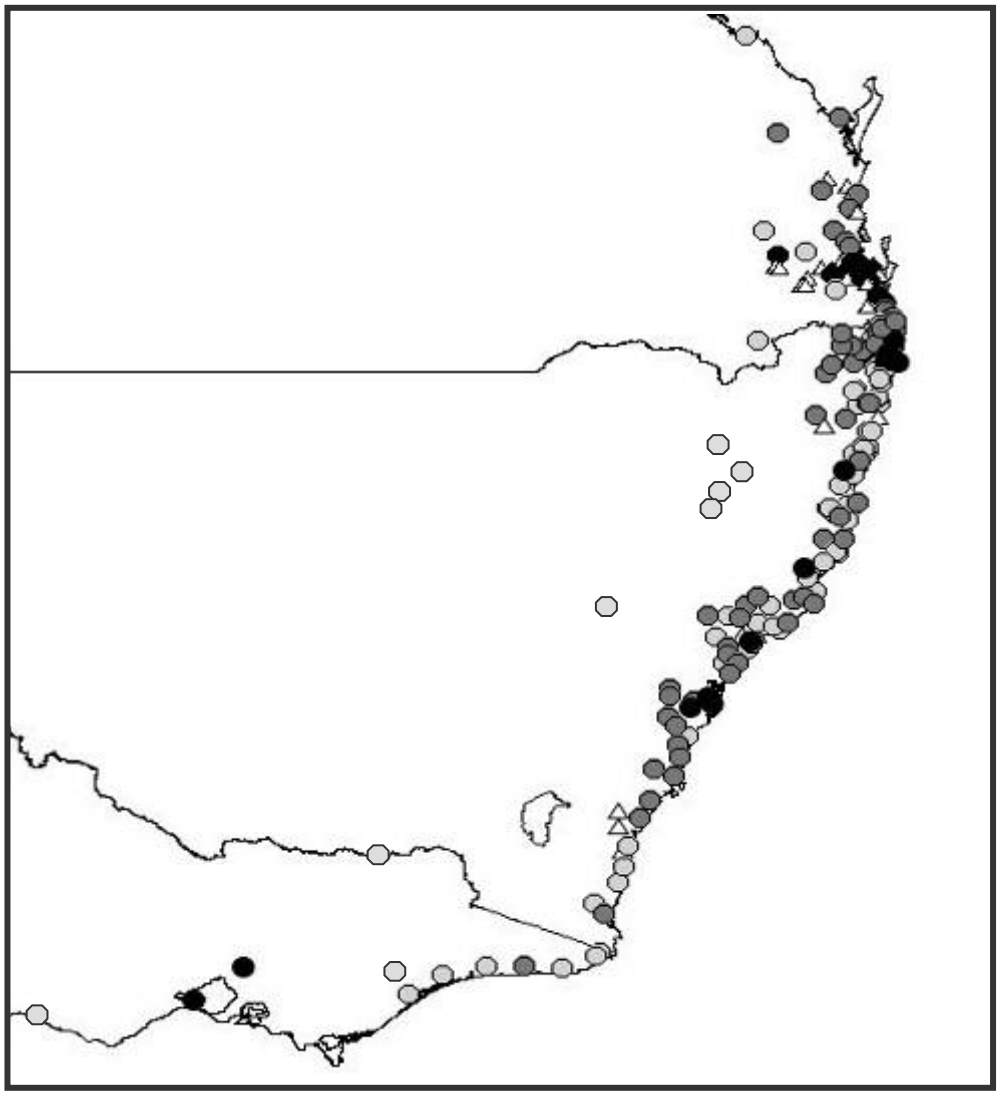


Figure 3: Locations of camps used by Grey-headed Flying-foxes, with indications of their patterns of use

● occupied continuously
● seasonal occupation > 80% of years
○ occupied < 80% of years
△ unknown, not continuous



2.4 Habitat critical to the survival of the species

In order to survive, Grey-headed Flying-foxes require a continuous sequence of productive foraging habitats, the migration corridors or stopover habitats that link them, and suitable roosting habitat within nightly commuting distance of foraging areas (Fleming and Eby 2003).

It should be noted that different jurisdictions have different legislative provisions and definitions of habitat critical to the survival of a species and of critical habitat. The legislative provisions and definition under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* apply to this national recovery plan.

A recovery plan for a nationally listed threatened species must identify the habitats that are critical to the survival of the species concerned and the actions needed to protect those habitats. S. 270(2)(d) of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* states that 'In particular, a recovery plan must (subject to subsection (2A)):

(d) identify the habitats that are critical to the survival of the species or community concerned and the actions needed to protect those habitats'

where subsection (2A) states that 'A recovery plan need only address the matters mentioned in paragraphs (2)(d), (e), (f), (g) and (h) to the extent to which it is practicable to do so.'

S. 37(1) of the New South Wales *Threatened Species Conservation Act 1995* states that 'The whole or any part or parts of the area or areas of land comprising the habitat of an endangered species, population or ecological community or critically endangered species or ecological community that is critical to the survival of the species, population or ecological community is eligible to be declared under this Part to be the critical habitat of the species, population or ecological community.'

That is, in New South Wales critical habitat can not be declared for a species listed as vulnerable under the *Threatened Species Conservation Act 1995*.

S. 13 of the Queensland *Nature Conservation Act 1992* states that

'(1) Critical habitat is habitat that is essential for the conservation of a viable population of protected wildlife or community of native wildlife, whether or not special management considerations and protection are required.

(2) A critical habitat may include an area of land that is considered essential for the conservation of protected wildlife, even though the area is not presently occupied by the wildlife.'

S. 20(1) of the Victorian *Flora and Fauna Guarantee Act 1988* states that 'The Secretary may determine that the whole or any part or parts of the habitat of any taxon or community of flora or fauna is critical to the survival of that taxon or community.'

Foraging habitat critical to survival

The majority of myrtaceous plants in the diet of Grey-headed Flying-foxes flower within a defined season but are not annually reliable, and the locations of productive foraging habitat provided by these plants vary (Law *et al*. 2000, Eby and Lunney 2002, Birt 2005). In most months it is not possible to predict what localities will be productive, and therefore what localities will provide essential habitat for the species. All foraging habitat has the potential to be productive during general food shortages and to therefore provide a resource critical to survival.

On the basis of current knowledge, foraging habitat that meets at least one of the following criteria can be explicitly identified as habitat critical to survival, or essential habitat, for Grey-headed Flying-foxes. Natural foraging habitat that is:

1. productive during winter and spring, when food bottlenecks have been identified (Parry-Jones and Augee 1991, Eby *et al.* 1999)
2. known to support populations of > 30 000 individuals within an area of 50 km radius (the maximum foraging distance of an adult)

3. productive during the final weeks of gestation, and during the weeks of birth, lactation and conception (September to May)
4. productive during the final stages of fruit development and ripening in commercial crops affected by Grey-headed Flying-foxes (months vary between regions)
5. known to support a continuously occupied camp.

Roosting habitat critical to survival

Grey-headed Flying-foxes roost in large aggregations in the exposed branches of canopy trees (Ratcliffe 1931, Nelson 1965a, Parry-Jones and Augee 1992). The locations of camps are generally stable through time, and several sites have documented histories that exceed 100 years (Lunney and Moon 1997). Camps provide resting habitat, sites of social interactions and refuge for animals during significant phases of their annual cycle, such as birth, lactation and conception (Parry-Jones and Augee 1992, 2001).

On the basis of current knowledge, roosting habitat that meets at least one of the following criteria can be explicitly identified as habitat critical to survival, or essential habitat, for Grey-headed Flying-foxes. Roosting habitat that:

1. is used as a camp either continuously or seasonally in > 50% of years
2. has been used as a camp at least once in 10 years (beginning in 1995) and is known to have contained > 10 000 individuals, unless such habitat has been used only as a temporary refuge, and the use has been of limited duration (i.e. in the order of days rather than weeks or months)
3. has been used as a camp at least once in 10 years (beginning in 1995) and is known to have contained > 2 500 individuals, including reproductive females during the final stages of pregnancy, during lactation, or during the period of conception (i.e. September to May).

Additional points:

1. In order to reduce conflict, camps in remnant vegetation should be isolated from human habitation by a management zone > 300 m wide. The extent of the management zone should be included in the definition of the camp. It should comprise habitat unsuitable for roosting by flying-foxes (cleared land, low shrubs or isolated trees). Residential development, schools and other structures that might lead to conflict should be excluded.
2. Where possible, the area of vegetation defined as a camp should be large enough to accommodate influxes of migratory animals and enable the colony to change location.
3. Camps that are critical to the survival of the species may consist of introduced plants.

2.5 Mapping of habitat critical to the survival of the species

Habitat critical to the survival of Grey-headed Flying-foxes has not been mapped. Actions under this recovery plan will produce maps of habitat critical to survival.

3 Known and potential threats

3.1 Biology and ecology relevant to threatening processes

Diet and foraging ecology. Grey-headed Flying-foxes feed primarily on blossom and fruit in canopy vegetation and supplement this diet with leaves (Ratcliffe 1931, Parry-Jones and Augee 1991, Eby 1995, 1998, Tidemann 1999, Hall and Richards 2000). The majority of animals feed on nectar and pollen from eucalypts (genera *Eucalyptus, Corymbia* and *Angophora*), melaleucas and banksias. Grey-headed Flying-foxes forage over extensive areas. One-way commutes of approximately 50 km have been recorded between camps and foraging areas (Eby 1991), although commuting distances are more often < 20 km (Tidemann 1999).

Flying-foxes disperse pollen and seeds of diet plants during their foraging bouts; in this way they participate in the reproductive and evolutionary processes of forest communities. The movement of genetic material via seed and pollen dispersal provides plants with a range of benefits, and various characteristics of Grey-headed Flying-foxes contribute to this species' role as a pollen and seed disperser. Their mobility, size, territorial feeding behaviour, and colonial habit result in wide-ranging dissemination of pollen and seeds (Eby 1996, Southerton *et al.* 2004, Birt 2005). The nightly foraging areas of individuals generally contain several trees that may be separated by distances exceeding 5 km (Eby 1996, Birt 2005). The ability of flying foxes to move freely among habitat types allows them to transport genetic material across fragmented, degraded and urban landscapes.

The foraging behaviour of Grey-headed Flying-foxes alters when native food is scarce. Individuals decrease the costs of foraging by reducing their coloniality. They roost individually, or in small groups, near feeding trees. Usual patterns of foraging behaviour are relaxed as animals come down close to the ground in search of food and increase the use of cultivated plants, particularly commercial fruit crops (Ratcliffe 1931, McWilliam 1986, Teagle 2002). Contact with humans increases in these circumstances, and greater numbers of animals are at risk of mortality from crop management practices.

Long distance movements. The majority of eucalypts have regular seasonal flowering schedules but do not flower every year, and there are few areas within the range of the Grey-headed Flying-fox where nectar is available continuously (House 1997, Wilson and Bennett 1999, Law *et al.* 2000). Grey-headed Flying-foxes have no adaptations for withstanding food shortages (e.g. torpor) and migrate in response to changes in the amount and location of food (Hall and Richards 2000). Evidence from broad-scale surveys, radio-telemetry and satellite-telemetry shows that adults and young can move hundreds of kilometres between productive habitats (Eby 1991, Spencer *et al.* 1991, Parry-Jones 1993, Augee and Ford 1999, Tidemann and Nelson 2004). In most areas within the species' range, patterns of migration and distribution vary considerably between seasons and between years (Eby and Lunney 2002). The mechanisms that flying-foxes use to locate stands of flowering trees are unknown and have not been studied. However, no speculative movements of large numbers of animals have been observed, and there is inferential evidence that information exchange plays a role in locating food.

Roosting ecology. Grey-headed Flying-foxes display a degree of flexibility in their choice of camp vegetation (Tidemann 1999, Peacock 2004, Roberts 2005). Camps are commonly located in closed forest, *Melaleuca* swamps or stands of *Casuarina* and are generally found near rivers or creeks (Ratcliffe 1932, Hall and Richards 2000). More open vegetation, including introduced species such as willows, poplars and pines, is used in southern and inland areas. Camps occur in vegetation ranging from continuous forest to remnants as small as 1 ha (Eby 2002, West 2002) and in southeast Queensland there is a propensity for camps to be situated in urban environments (Roberts 2005, 2006). Optimal roosting conditions have not been described, and the relative benefits of using sites of different floristic or structural traits need further investigation (Tidemann 1999, Peacock 2004, Roberts 2005).

Patterns of camp occupation vary, ranging from sites that are inhabited continuously to those that are inhabited only rarely (Parry-Jones 1993, Eby 1995). Although many camps have distinguishable seasonal cycles of occupation, annual variations can be extreme, and peak population size can exceed 50 000 (Ratcliffe 1931, Parry-Jones and Augee 1992, Parry-Jones 1993, Eby *et al*. 1999, Birt 2000). The number of flying-foxes in most camps is primarily related to the amount of food available within nightly commuting distance, although the annual reproductive cycle also influences the stability and size of populations (Ratcliffe 1931, Nelson 1965a, Parry-Jones and Augee 2001, Birt 2005).

Camps are used as day refuges by animals that forage in surrounding areas over several weeks, and as short-term stopover sites by migrating animals (Eby 1991, 1995, Tidemann and Nelson 2004). They are the sites of social behaviours associated with reproduction and maternal care (Nelson 1965b, Markus and Blackshaw 2002, Connell *et al.* 2006). For several weeks in late spring and summer they provide refuge for flightless young. Vocalisations associated with territorial disputes and mother–infant recognition are most concentrated pre-dawn, when animals return to camps (Markus and Blackshaw 2002). The majority of trees are occupied by groups of mixed-sex adults. These groups comprise a single male, who scent-marks and defends a territory shared by one or more females who may have dependent young (Nelson 1965b, Markus and Blackshaw 2002). Males mate with females that occupy their territories, and polygamy is common.

When undisturbed, camp locations are generally stable through time (Lunney and Moon 1997). This characteristic applies to camps that are used on an annual basis as well as those that are used infrequently. It is unclear whether the capacity of Grey-headed Flying-foxes to locate infrequently used sites is a result of a well-developed spatial memory in a long-lived species, or of the specific qualities of camps. For example, the Palm Grove in the Royal Botanic Gardens Sydney contained Grey-headed Flying-foxes for short periods in 1858, 1900, 1916, 1920 and 1989 (A. Leishman pers. comm., Royal Botanic Gardens Sydney). It is unlikely that this pattern of occupation can be attributed to memory alone. The site may have physical characteristics that are attractive to the species.

Grey-headed Flying-foxes alter the vegetation of camps, particularly those in small patches of remnant forest or public gardens (Hall 2002, Richards 2002). Roosting animals defoliate trees and break end branches. Concerns exist regarding the effects of periodic defoliation on photosynthesis and reproduction, the effects of reduced canopy cover on establishment rates of exotic weeds, and the effects of faecal material on soil nutrient levels (Floyd 1990, Pallin 2000). When camps occur in large remnants the animals move within the available space through time, providing opportunities for roost trees to recover (Hall 2002). Pressure on trees is more consistent in small remnants and gardens (Richards 2002, West 2002). Flying-fox camps have been incorporated into successful habitat regeneration programs in locations such as Wingham Brush, Bellingen Island, Currie Park (Lismore) and Gordon (Sydney) (e.g. Pallin 2000).

Breeding. Reproduction in Australian flying-foxes is seasonal and synchronous (Ratcliffe 1931, Nelson 1965b, O'Brien 1993). Grey-headed Flying-foxes give birth to single pups in October or November (Martin and McIlwee 2002) and lactate approximately to March. Mating behaviour commences in January and conception occurs in April or May (Nelson 1965b, O'Brien 1993, Martin *et al*. 1996). Individuals reach reproductive maturity in the second year of life. However, there is evidence that few females younger than three years successfully raise young to independence (McIlwee and Martin 2002). This low reproductive potential inhibits the capacity of Grey-headed Flying-foxes to recover from population declines (McIlwee and Martin 2002).

Relationship with other Australian flying-foxes. The range of Grey-headed Flying-foxes overlaps with those of two other flying-fox species, Black Flying-foxes and Little Red Flying-foxes. Grey-headed Flying-foxes and Black Flying-foxes are closely related species that share many behavioural and ecological characteristics. In regions where their ranges overlap, their diet lists are equivalent (Hall and Richards 2000, Birt 2005). There is no evidence that foraging behaviours differ, although this has not been a specific area of research. Both species are highly

colonial and share camp sites, within which they segregate spatially (Ratcliffe 1932, Nelson 1965a, McWilliam 1986, Birt and Markus 1999, Eby 2004). In addition, both species are synchronous, seasonal breeders and their annual reproductive cycles are closely aligned at subtropical latitudes (Nelson 1965b, Webb and Tidemann 1995, Martin *et al.* 1996). Grey-headed Flying-foxes and Black Flying-foxes hybridise and produce fertile offspring (G. O'Brien, University of New England unpublished data), although rates of hybridisation in wild populations are unknown (Webb and Tidemann 1995). Little Red Flying-foxes irregularly occupy camps used by Grey-headed Flying-foxes and also share diet plants (Ratcliffe 1931, Nelson 1965a, Birt and Markus 1999, Hall and Richards 2000). Their reproductive schedule is approximately six months out of phase with those of the other two species, and hybridisation with Grey-headed Flying-foxes has not been observed (Ratcliffe 1931, Nelson 1965b, O'Brien 1993, Martin *et al.* 1996).

Disease. During the mid-1990s Australian flying-foxes were identified as natural reservoirs of three newly-described zoonotic diseases: a rabies-like disease, Australian bat lyssavirus (ABL), and two paramyxoviruses, Hendra virus (also known as equine morbillivirus) and Menangle virus (Philbey *et al.* 1998, Halpin *et al.* 2000, Hanna *et al.* 2000). ABL is a fatal disease that is transmitted to humans through bites or scratches when the saliva of infected bats comes into contact with an open wound (Anon 1996). There is no evidence that this or other rabies-like viruses can be transmitted through urine or faeces. Effective pre-exposure and post-exposure protection from ABL is available through a vaccine that can be administered by medical practitioners. There is no evidence that the two paramyxoviruses can be transmitted directly from bats to humans, although each has been transmitted to humans by domestic animals (horses and pigs) (H. Field pers. comm., Queensland DPI, T. Ross pers. comm., NSW Agriculture). The disease risk to the general bat population and to humans remains an active area of research (e.g. Barrett 2004, Barrett *et al.* 2005).

3.2 Identification of threats

Habitat loss: High Priority Threat

Foraging habitat. Loss of foraging habitat is consistently identified as the primary threat to Grey-headed Flying-foxes (Ratcliffe 1931, Tidemann *et al.* 1999, Dickman and Fleming 2002, Eby and Lunney 2002). Reductions in nectar flow and fruit productivity occur as a result of forest clearance and degradation, reductions in floristic diversity, simplification of age structure from forestry practices, eucalypt dieback, drought, fire, climate change and the vulnerability of flowering and fruiting schedules to fluctuations in such factors as temperature and rainfall (Norton 1996, House 1997, Wilson and Bennett 1999, Law *et al.* 2000, Hughes 2003). Clearing of native vegetation for agriculture, forestry operations, plantation plantings, and development continue to reduce food production from eucalypts and other native species in the diet of Grey-headed Flying-foxes (Accad *et al.* 2001, Wilson *et al.* 2002, Queensland Department of Natural Resources and Mines 2005). Plant communities in coastal areas exposed to rapid increases in human population are severely affected (Catterall *et al.* 1997, Williams *et al.* 2001, Keith and Scott 2005).

The complexity of the habitat requirements of the Grey-headed Flying-fox—particularly its requirement for multiple, geographically dispersed populations of food trees—militates against conserving foraging habitats within a system of conservation reserves and leaves the species vulnerable to land-use decisions in unreserved forests (Parry-Jones 1993, Pressey 1994, Eby 1996, Tidemann and Vardon 1997). The clearing of habitat continues as a threat to the Grey-headed Flying-fox. Sources of clearing include that undertaken for rural development, and for urban and infrastructural development. Significant areas are also cleared to establish commercial hardwood and softwood plantations. Many habitats cleared in recent years are those that were retained under earlier land-use regimes because of a lack of agricultural potential (Catterall *et al.* 1997). The impacts of clearing are difficult to predict with accuracy and are unlikely to be manifested immediately owing to the irregular nature of eucalypt flowering.

Clearing of winter forage is a particular concern for the species. Few diet plants flower in winter, and those that flower reliably occur on coastal lowlands in northern New South Wales and southern Queensland (Eby *et al.* 1999, Eby and Lunney 2002). Grey-headed Flying-foxes congregate in these habitats. The vegetation communities that contain winter-flowering *Eucalyptus tereticornis* (Forest Red Gum), *Eucalyptus robusta* (Swamp Mahogany) and *Melaleuca quinquenervia* (Five-veined Paperbark) have been substantially cleared, are poorly represented in conservation reserves, occur primarily on privately owned land and continue to be cleared at high rates (Catterall *et al.* 1997, Sattler and Williams 1999, Accad *et al.* 2001, Wilson *et al.* 2002, Keith and Scott 2005). Substantial tracts are zoned for residential development and rural use. For example, approximately 62% of the remaining swamp vegetation containing *M. quinquenervia* or *E. robusta* in the Coffs Harbour Local Government Area is zoned for land use that makes it available for development under the current Local Environment Plan (K. Taylor pers. comm., formerly of Coffs Harbour City Council). Studies of rates of clearing in southeast Queensland indicate that 0.7% to 1.1% of the remaining vegetation that contains key winter-flowering species is cleared each year (Accad *et al.* 2001, and unpublished data of the Queensland Herbarium).

There is evidence that spring forage is currently inadequate to provide reliable resources during critical periods in the reproductive cycle of Grey-headed Flying-foxes. The species is subject to recurring food shortages during late gestation, birth and early lactation; these shortages are associated with rapid weight loss in adults and poor reproductive success (Eby 1999, Collins 2000, Parry-Jones and Augee 2001). Spring food shortages have been reported over large portions of the range in six of the past 20 years, and more frequently in some local areas (Parry-Jones and Augee 2001, Teagle 2002, B. White pers. comm., NSW Agriculture). Their impact is exacerbated by associated increases in the use of commercial fruit crops, exposing Grey-headed Flying-foxes to destructive crop management regimes (Teagle 2002).

Roosting habitat. Loss of roosting habitat has also been identified as a threat to Grey-headed Flying-foxes (Tidemann *et al.* 1999, NSW Scientific Committee 2001). Camp vegetation has been exposed to the same historical patterns of clearing and degradation as has foraging habitat (Lunney and Moon 1997, Hall 2002). The roosting requirements of Grey-headed Flying-foxes are not known, nor are the impacts on the species of loss of long-term sites, which may be selected to meet specific requirements. The degradation of vegetation in small remnants threatens longevity and may also reduce the suitability of sites as camps (Pallin 2000).

Deliberate destruction associated with commercial horticulture: High Priority Threat

Grey-headed Flying-foxes have caused damage to cultivated fruit crops since the time of European settlement (Ratcliffe 1931, Tidemann *et al.* 1997). Crops grown in coastal areas north from the Illawarra are most commonly affected, although the increase in occurrence of Grey-headed Flying-foxes in eastern Victoria in the past 20 years has been associated with locally significant and sporadic crop damage in that region (I. Temby pers. comm., Victorian Department of Sustainability and Environment). Levels of damage vary considerably between localities and years (Teagle 2002). There is evidence that some relatively new crops such as lychees and some varieties of bananas sustain particularly high levels of damage (Rogers 2002, Teagle 2002).

Shooting is the method most commonly used to protect crops against flying-fox damage (Teagle 2002). The effectiveness of shooting as a crop protection method has not been quantified. Growers report that shooting provides adequate protection in years of low flying-fox pressure but is ineffective in years of severe attack (Comensoli 2002, Teagle 2002). The numbers of animals shot is unknown, but past estimates have been as high as 100 000 a year (Wahl 1994, Vardon and Tidemann 1995), with the majority of animals killed being pregnant and lactating females (Tidemann *et al.* 1997, Parry-Jones and Augee 2001). State-based permit systems regulate the kill (McKinnon *et al.* 2002, Waples 2002). A nationally agreed limit for damage mitigation licences to 1.5% of the population size was put in place in 2002, when Grey-headed

Flying-foxes were listed as Vulnerable under the EPBC Act (Department of the Environment and Heritage 2003a). Compliance monitoring is problematic, and substantial unlicensed deliberate destruction has been reported (Wahl 1994, Vardon and Tidemann 1995, Richards 2000, McLachlan 2002, Waples 2002, Ballard 2004). There are animal welfare issues associated with the unknown accuracy of shots fired at flying animals at night and the extent of injuries sustained by animals that are not killed immediately. The impact of deliberate destruction of flying-foxes in crops on the size and demographic structure of the population is unknown.

It should be noted that as of 1 September 2008, the Queensland Government no longer permits the killing of flying-foxes for crop protection. The move follows a finding by the Queensland Government's Animal Welfare Advisory Committee that shooting flying-foxes for crop protection is inhumane. A strategic compliance program will be undertaken to manage instances of illegal shooting.

Competition with Black Flying-foxes: Threat Priority Unknown

Ecological processes influence the distribution of species. The observed changes in the distribution of flying-fox species in Australia and the interaction of these flying-fox species are natural processes that are influenced by factors such as climate change. That is, the interaction between the Grey-headed and the Black Flying-fox is a natural process. Expansion of the southern limit of Black Flying-foxes has increased the area of overlap with Grey-headed Flying-foxes (Figure 4), and the movement of Black Flying-foxes into new areas has consistently been followed by an increase in abundance relative to that of Grey-headed Flying-foxes. This has occurred in floristically diverse regions east of the escarpment that provide continuous food and suitable camps for both species. There is no evidence that Black Flying-foxes and Grey-headed Flying-foxes use agonistic behaviours to compete directly for resources (N. Markus pers. obs., P. Eby pers. obs.). However, the increasing displacement of Grey-headed Flying-foxes suggests that indirect competition favours Black Flying-foxes.

The ongoing nature of shifts in the southern limit of Black Flying-foxes can be traced through studies conducted in the 1920s (Ratcliffe 1931), 1960s (Nelson 1965a) and 1990s (Eby and Palmer 1991, Eby 1995) and through surveys conducted from 1998 to 2004 (Eby *et al.* 1999, Eby 2004). In each study, range boundaries were defined by inspecting populations of communal roosts. Extra-limital sightings or vagrancy can confound assessments of range boundaries in highly mobile, migratory species such as flying foxes. In this summary, extra-limital sightings are defined by number of individuals, reproductive status and duration of stay. Sightings of < 50 non-breeding individuals or a single sighting of > 50 individuals of < 4 weeks duration are considered extra-limital and are not included in the assessment.

Between 1930 and 1960 the southern limit of the range of Black Flying-foxes moved south by approximately 300 km from the Mary River in Queensland to the Tweed River in New South Wales (Figure 4). In 1990 the southernmost camp used by the species was located 40 km farther south, at the mouth of the Richmond River. However, it is unclear whether this represented a shift in range, as camps located between the Richmond and Tweed rivers were not surveyed in the 1960s study. From 1990 to 2004 the southern limit of Black Flying-foxes shifted rapidly, by a total of about 350 km, to the Manning River. A dead neonate was found in Newcastle in 2005, and adults of both sexes and neonates have been recorded in the Newcastle camp since 2006. In that year, approximately 75 individuals, including breeding females and dependent young, were also observed roosting in the Royal Botanic Gardens Sydney. The southern limit had shifted a further 250 km in two years. In 2007 the population estimate in the Royal Botanic Gardens Sydney was 120. Small numbers of Black Flying-foxes (< 10) were recorded in the Kurnell camp in Sydney in February 2008. These sightings are not included in Figure 4. The NSW Scientific Committee made a final determination in August 2008 to de-list the Black Flying-fox from the schedules of the New South Wales *Threatened Species Conservation Act 1995*.

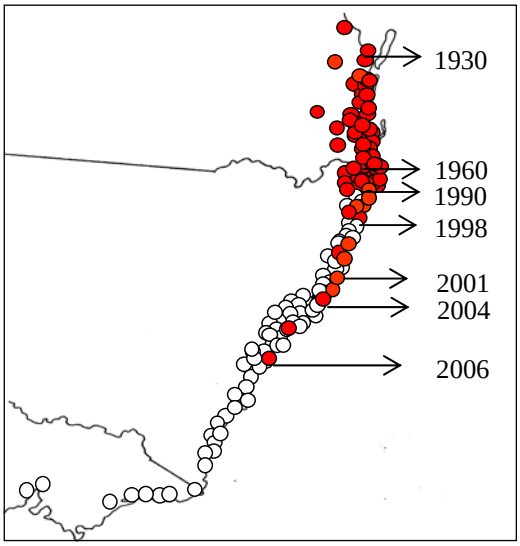


Figure 4: Timing and extent of southern extensions to the range of Black Flying-foxes

This map shows camps used by Black Flying-foxes during national surveys from 1998 to 2004, and the 2006 sightings in Newcastle and the Royal Botanic Gardens Sydney (filled circles). Open circles represent camps occupied by Grey-headed Flying-foxes and not Black Flying foxes. Within the area of overlap, all camps used by Black Flying-foxes are also used by Grey-headed Flying-foxes.

Relative abundance of Black Flying-foxes. Expansions to the range of Black Flying-foxes have consistently foreshadowed an increase in the local abundance of the species relative to that of Grey-headed Flying-foxes. During the past 20 years the numbers of Grey-headed Flying-foxes relative to those of Black Flying-foxes have declined markedly in coastal areas north from the Clarence Valley and in the tablelands of southeast Queensland (Birt 2000, Hall 2002, Eby 2004, B. Thomson Queensland Environmental Protection Agency unpublished). In 1960, Black Flying-foxes were found in small numbers (50 to 500) in camps from Nambour, Queensland, to the Tweed River (Nelson 1965a). Camps in this region were not monitored in the 1990s study. However, more recent work documented a substantial escalation in the relative abundance of Black Flying-foxes in all camps in the area (Eby *et al.* 1999, Birt 2000, Eby 2004). The rate of increase in northern New South Wales has been particularly rapid in the past 10 years.

Negative public attitudes and conflict with humans: Medium Priority Threat

Conflict between humans and Grey-headed Flying-foxes is an ongoing and apparently increasing problem that particularly affects camps in coastal areas (Smith 2002, Tidemann 2002, West 2002). Conflict and negative perceptions of Grey-headed Flying-foxes can impact the population directly through harassment and deliberate destruction, or indirectly by inhibiting or impeding community support for conservation initiatives. In recent years the incidence of interactions between humans and Grey-headed Flying-foxes has apparently risen. A rapid increase in the human population of coastal Queensland and New South Wales has caused camps that were once isolated from human activities to be increasingly surrounded by urban and rural residential development (Smith 2002, West 2002, Coffs Harbour City Council 2004). The population size and continuity of occupation of camps in metropolitan areas have also increased (Birt *et al.* 1998, Hall 2002, Richards 2002, van der Ree *et al.* 2006). This trend has been associated with an increase in the density and diversity of food trees in the gardens and streetscapes of cities like Sydney and Melbourne, together with increasing pressures on Grey-headed Flying-foxes in non-urban landscapes from reductions in the availability of native forage and increasing competition from Black Flying-foxes (Birt *et al.* 1998, Hall and Richards 2000, Parry-Jones and Augee 2001, Hall 2002).

People living near camps are exposed to several annoyances, including both the noise from vocal communications of animals during the day and pre-dawn when they return from foraging and the pungent smell created by the dense concentration of animals. People in close proximity are also likely to be concerned about disease (Eby 1995, Tidemann 1999, Smith 2002). Active or aggressive disturbances (sometimes including deliberate destruction), have been used in attempts to remove animals from camps (Lunney and Moon 1997, Tidemann 1999, 2002, Hall

2002). Efforts to break the fidelity of Grey-headed Flying-foxes to specific camps have generally been unsuccessful. In the few situations where the animals have moved, ongoing programs of disturbance have been required to keep them away. An exception is the experience at the Royal Botanic Gardens Melbourne, where no ongoing disturbances have been required (S. Toop pers. comm., Victorian Department of Sustainability and Environment). It has not been possible to precisely pre-determine the locations of replacement roosts, and problems with conflict can shift to different sites (Hall 2002). There is a growing view that it is best to manage camps where they are and develop strategies to reduce their impact.

Electrocution on powerlines, entanglement in netting and on barbed-wire: Low Priority Threat

Grey-headed Flying-foxes are prone to accidental injury and death from various artificial obstacles. They are prone to electrocution on powerlines, particularly in urban areas, and increasing urbanisation of the population exposes larger proportions to electrocution (Tidemann 1999, K. Parry-Jones, University of Sydney unpublished data). Animals become entangled in fine gauge netting that is draped loosely over backyard fruit trees. Entanglement on barbed-wire affects animals in rural areas, although the incidence of this is unknown.

Climate change: Threat Priority Unknown

Climate change in the coming decades has the potential to affect food availability and heat-related mortality in Grey-headed Flying-foxes. Current models of climate change predict that mean maximum temperatures in southeast Australia will rise (Pittock and Wratt 2001). Many eucalypts have a narrow range of tolerance to temperature and rainfall, and the predicted levels of change are expected to impact distribution and reproduction (Hughes *et al.* 1996, Hughes 2003). Regional trends in honey yield have been identified as potential indicators of the impacts of climate change on biodiversity (Department of the Environment and Heritage 2003b). The occurrence of extreme temperatures is also predicted to rise. Exposure to high temperatures results in mortality in Grey-headed Flying-foxes (Parry-Jones 2000, Eby *et al.* unpublished, Welbergen *et al.* 2007). Mortality rates are low at ambient temperatures of 41 to 43.5º C but increase rapidly at temperatures > 43.5º C, particularly affecting flightless young.

Disease: Low Priority Threat

Grey-headed Flying-foxes are reservoirs of three recently-described zoonotic diseases (Field 2002). Australian bat lyssavirus (ABL) can cause clinical disease and mortality in Grey-headed Flying-foxes. The incidence of ABL in the species is low (< 1%). The virus appears to have evolved with the bats and generally is in equilibrium with the population (H. Field pers. comm., Queensland Department of Primary Industries). However, when flying-foxes undergo significant ecological stress, the incidence of ABL can increase to the point where the disease is no longer in equilibrium and the population is impacted. No clinical disease or mortality in flying-foxes is associated with Hendra virus or Menangle virus (H. Field pers. comm., Queensland Department of Primary Industries, T. Ross pers. comm., NSW Agriculture).

3.3 Areas and populations under threat

The processes that threaten Grey-headed Flying-foxes are most prevalent in coastal areas north from the Sydney Basin. Rates of forest clearing and modification are high in this region, as are rates of increase in the human population. The region supports large and varied commercial fruit growing operations, and it is experiencing a rapid increase in abundance of Black Flying-foxes. These coastal areas also support the greatest natural diversity of food plants and the most consistent presence of the species outside metropolitan areas. A range of management issues and responses have been explored and implemented in these areas, with varying degrees of success (see Nelson 2008, and Department of Environment and Climate Change 2008).

4 Objectives, criteria and actions

4.1 Recovery objectives and timelines

Overall objectives

The overall objectives of recovery are:

- to reduce the impact of threatening processes on Grey-headed Flying-foxes and arrest decline throughout the species' range
- to conserve the functional roles of Grey-headed Flying-foxes in seed dispersal and pollination
- to improve the standard of information available to guide recovery of the Grey-headed Flying-fox, in order to increase community knowledge of the species and reduce the impact of negative public attitudes on the species.

Specific objectives

Specific objectives to be met in the 5-year timeframe of this recovery plan are listed below, not in priority order. Initiatives to meet these objectives will incorporate principles of sustainable development and promote procedures to minimise significant adverse social and economic impacts, such as the use of environmental incentive schemes and equitable cost-sharing arrangements.

- *Objective 1.* To identify and protect foraging habitat critical to the survival of Grey-headed Flying-foxes throughout their range
- *Objective 2.* To protect and increase the extent of key winter and spring foraging habitat of Grey-headed Flying-foxes
- *Objective 3.* To identify roosting habitat critical to the survival of Grey-headed Flying-foxes
- *Objective 4.* To protect and enhance roosting habitat critical to the survival of Grey-headed Flying-foxes
- *Objective 5.* To substantially reduce deliberate destruction of Grey-headed Flying-foxes in fruit crops
- *Objective 6.* To reduce negative public attitudes toward Grey-headed Flying-foxes and reduce conflict with humans
- *Objective 7.* To increase public awareness and understanding of Grey-headed Flying-foxes and the recovery program, and to involve the community in recovery actions, where appropriate, to reduce the threat of negative public attitudes and conflict with humans
- *Objective 8.* To monitor population trends in Grey-headed Flying-foxes so as to monitor the species' national distribution and status
- *Objective 9.* To assess and reduce the impact on Grey-headed Flying-foxes of electrocution on powerlines and entanglement in netting and on barbed-wire
- *Objective 10.* To improve knowledge of the demographics and population structure of Grey-headed Flying-foxes in order to increase understanding of the ecological requirements of the species
- *Objective 11.* To increase the effectiveness and efficiency of recovery initiatives for Grey-headed Flying-foxes by working cooperatively with conservation and management programs with overlapping objectives to remove or reduce the impact of threatening processes on the species
- *Objective 12.* To maintain an effective Grey-headed Flying-fox National Recovery Team to oversee the implementation of the Grey-headed Flying-fox National Recovery Plan to remove or reduce the impact of threatening processes on the species.

- *Objective 13.* To provide long-term economic benefits associated with the protection of ecosystem services, promotion of sustainable forest management, improved crop protection regimes, promotion of sustainable agricultural practices and increased viability of some commercial fruit industries.

4.2 Performance criteria

The following performance criteria are to be used to assess achievement of the above objectives and are to be met in the 5-year life of this recovery plan:

- *Criterion 1*. Foraging habitat critical to survival of Grey-headed Flying-foxes identified and the extent of this habitat that is protected under conservation management programs increased
- *Criterion 2*. The extent of Grey-headed Flying-fox winter and spring foraging habitat that is protected under conservation management programs increased, and tree-planting and habitat rehabilitation programs to extend winter and spring foraging habitat implemented
- *Criterion 3.* Camps critical to the survival of Grey-headed Flying-foxes identified and mapped
- *Criterion 4.* The number of Grey-headed Flying-fox camps critical to survival that are protected under conservation management programs increased
- *Criterion 5.* Damage to orchard industries by Grey-headed Flying-foxes reduced and deliberate destruction in crops substantially reduced
- *Criterion 6.* Increase in uptake of effective non-lethal flying-fox control practices by orchard industries
- *Criterion 7.* Both negative public attitudes toward Grey-headed Flying-foxes and conflict with humans reduced
- *Criterion 8.* Educational material for increasing public awareness and understanding of Grey-headed Flying-foxes and the recovery program developed and circulated, and members of the general community involved in recovery actions
- *Criterion 9.* Methods for assessing abundance in Grey-headed Flying-foxes improved, error in abundance measures estimated, and population trends monitored
- *Criterion 10.* The incidence of Grey-headed Flying-fox electrocution on powerlines and entanglement in netting and on barbed-wire assessed and reduced
- *Criterion 11*. Knowledge of the demographics and population structure of Grey-headed Flying-foxes improved
- *Criterion 12.* Cooperative alliances formed with appropriate conservation programs
- *Criterion 13*. Strategic direction and coordination between State and Australian Government agencies for implementation of the Grey-headed Flying-fox National Recovery Plan.

4.3 Evaluation of performance

The recovery objectives seek to determine initial benchmarks to enable future monitoring and performance evaluation of the suggested recovery actions, and to track their effectiveness in recovering the Grey-headed Flying-fox. A recovery team will be established to manage and review the performance of the recovery plan. The team will evaluate success or failure against criteria set out in the plan. The recovery team will meet annually to discuss progress and, if necessary, to revise actions. Written reports evaluating performance against criteria will be provided to the Department of the Environment, Water, Heritage and the Arts after three and five years. The recovery team should include representatives of the conservation agencies of each of the three range States and of the Australian Government, representatives of primary stakeholders, and at least one person with scientific expertise suitable for evaluating the progress of research actions.

4.4 Actions for recovery

Actions for recovery of Grey-headed Flying-foxes are listed below. Some underlying principles of the actions are:

- Range-wide, integrated strategies of habitat protection are needed to conserve Grey-headed Flying-foxes. Priority habitats need to be identified and direct actions taken to incorporate the needs of the species into pre-existing mechanisms for protecting, enhancing and rehabilitating native vegetation, particularly on privately-owned land.
- Neither Grey-headed Flying-foxes nor commercial fruit industries are well served by current programs that aim to regulate deliberate destruction in crops. Grey-headed Flying-foxes are best protected from deliberate destruction in crops by eliminating their financial impact on commercial fruit industries and thereby removing the imperative to kill.
- Recovery of Grey-headed Flying-foxes cannot occur without wide community participation. In several areas, negative public attitudes toward the species act as an impediment to the recovery process. Strategic programs of public education and programs to reduce conflict are needed to address this problem.

Action 1: Identify and protect foraging habitat critical to the survival of Grey-headed Flying-foxes across their range

Objectives 1, 2, 7 and 11

Background. This set of actions aims to improve conservation outcomes for Grey-headed Flying-foxes by developing and implementing a range-wide, integrated strategy of habitat protection. Priority habitat will be identified and opportunities will be sought to protect priority habitat by using the range of instruments and procedures available under Federal, State and local government authorities. On privately-owned land, preference will be given to incentive-based programs and voluntary conservation arrangements. Integral to the process will be a program to educate land managers, decision-makers and the general public about the habitat requirements of Grey-headed Flying-foxes and to promote the biodiversity and economic benefits of conserving foraging habitats.

Action 1.1: Set priorities for protecting foraging habitat and generate maps of priority habitat for the Grey-headed Flying-fox
Priority 1
Action has commenced

- Set priorities for habitat protection on the basis of both importance to Grey-headed Flying-foxes and conservation status.
- Incorporate priorities into existing habitat maps.
- Identify areas of overlap between priority habitats for Grey-headed Flying-foxes and those of other threatened fauna and flora, particularly nectar- or fruit-feeding birds and mammals, and vulnerable and endangered vegetation communities.
- Inform appropriate staff of Department of the Environment, Water, Heritage and the Arts and State wildlife management and planning agencies of maps of ranked habitat, and provide copies as required.

Year	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL
Total	$30,000	0	0	0	0	$30,000

Action 1.2: Protect and enhance priority foraging habitat of the Grey-headed Flying-fox
Priority 1
Action has commenced

- Identify opportunities to protect and enhance priority habitats identified in Action 1.1 under instruments such as clearing regulations for native vegetation, State and Commonwealth threatened species legislation, forestry management plans, regional natural resource management plans, catchment management plans, local government environmental plans and development assessments, voluntary conservation agreements and Land for Wildlife programs.
- Particular emphasis should be placed on incorporating priority habitat on privately-owned land into available incentive-based or volunteer conservation programs.
- Promote protection and enhancement under these procedures through direct contact with appropriate authorities or individuals.
- Provide to authorities any background information or data they require for their decision-making processes (e.g. habitat definitions and maps of priority habitats). Material should be provided in a format appropriate to their systems. Broader biodiversity benefits, such as benefits to other threatened taxa, and economic benefits, such as implications for the fruit, forestry and apiary industries, should be highlighted in background material.
- Collaborate with other conservation initiatives.

Summary information is to be incorporated into actions under this recovery plan to inform and educate stakeholders and the general public.

Year	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL
Total	$27,000	$9,500	$9,500	$9,500	$9,500	$65,000

Action 2: Enhance winter and spring foraging habitat for Grey-headed Flying-foxes

Objectives 2, 5, 7 and 11

Background. Evidence of repeated food shortages during winter and spring indicates that inadequate productive foraging habitat exists in these seasons to sustain the current Grey-headed Flying-fox population. Pre-existing tree-planting and habitat restoration and rehabilitation programs provide vehicles for increasing the extent and viability of habitats productive in these seasons.

Action 2.1: Increase the extent and viability of foraging habitat for the Grey-headed Flying-fox that is productive during winter and spring
Priority 1

- Set regional priorities for tree-planting, restoration and rehabilitation work to increase the extent of, and protect the viability of, habitat containing plants important to Grey-headed Flying-foxes during winter and spring.
- Describe the broader biodiversity benefits of priority work, such as benefits to other threatened taxa, and the economic benefits, such as implications for the fruit, forestry and apiary industries.
- Develop material to promote priority plants to existing tree-planting and habitat restoration and rehabilitation programs, as well as to the agencies and instruments that support them, such as local government, catchment management authorities, natural resource management plans, and farm forestry operations.
- Promote priority plants for Grey-headed Flying-foxes by actions such as direct contact with individual agencies and groups and presentations at conferences.
- Collaborate with other conservation initiatives.

Summary information is to be incorporated into actions under this recovery plan to inform and educate stakeholders and the general public.

Year	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL
Total	$14,000	$14,000	$14,000	$14,000	$14,000	$70,000

Action 3: Identify, protect and enhance roosting habitat critical to the survival of Grey-headed Flying-foxes

Objectives 3, 4 and 7

Action 3.1: Establish and maintain a range-wide database of Grey-headed Flying-fox camps
Priority 2
Action has commenced

- Database to include information pertinent to management, including location, tenure, local government area, land-use zoning, species of flying-fox and history of use.
- Generate and circulate to relevant land management and planning authorities, researchers and interested public range-wide digital maps of camp localities, including point localities and shape files showing the boundary of the maximum area used by roosting animals. Include shape files of nominal buffer zones for limited development, as described in Section 2 of this recovery plan.
- Lodge the data with relevant State and Australian Government conservation agencies and put in place formal inter-agency data-sharing arrangements.

Summary information is to be incorporated into actions under this recovery plan to inform and educate stakeholders and the general public.

Year	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL
Total	$15,000	0	$10,000	0	$10,000	$35,000

Action 3.2: Improve knowledge of Grey-headed Flying-fox camp locations, particularly in inland areas
Priority 2
Action has commenced

- Undertake surveys of Grey-headed Flying-foxes that target regional areas and seasons where information is notably incomplete, such as inland areas during spring and summer.
- Promote public participation in surveys and reporting of camp locations.

Year	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL
Total	$25,000	0	$10,000	0	$10,000	$45,000

Action 3.3: Protect roosting habitat critical to the survival of the Grey-headed Flying-fox
Priority 1
Action has commenced

- Identify camps critical to the survival of Grey-headed Flying-foxes by using criteria set out in Section 2 of this recovery plan.
- Promote protection of camp vegetation under instruments such as local government environmental plans and development assessments, regional development plans, catchment management plans, forestry management plans, voluntary conservation agreements and Land for Wildlife programs.

- Promote the protection of management zones around camp vegetation, as described in Section 2 of this recovery plan.
- Develop information packages for local government planners and other land managers aimed at encouraging protection of camps and prohibiting inappropriate development in exclusion zones. Promote the value to humans of this approach. Include information on flying-fox biology, issues of community concern such as noise and disease, and summaries of recent management experiences at flying-fox camps (see Actions 5 and 6).
- State agencies to review the application of their relevant camp management policies by Year 5.

Year	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL
Total	$14,000	$12,750	$12,750	$12,750	$12,750	$65,000

Action 3.4: Determine the characteristics of roosting habitat for the Grey-headed Flying-fox
Priority 2
Action has commenced

- Conduct a program of research to explore the roles of characteristics such as floristic composition, vegetation structure, microclimate and landscape features in defining optimum roosting habitat.

Year	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL
Total	0	0	$15,000	$15,000	0	$30,000

Action 3.5: Enhance and sustain the vegetation in camps that are critical to the survival of the Grey-headed Flying-fox
Priority 2

- Incorporate the results of Action 3.4 into management recommendations for camps.

Year	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL
Total	0	0	0	0	$5,000*	$5,000*

* Total action cost is undetermined, as it is contingent on Action 3.4. Cost estimate provided is for the dissemination of the findings of Action 3.4.

Action 3.6: Investigate the interactions between the Grey-headed Flying-fox and the Black Flying-fox
Priority 3

- Identify what is causing the change in the interaction between the Grey-headed Flying-fox and the Black Flying-fox in terms of distribution, and the potential implications for both species.
- Identify the level of threat this interaction poses for the Grey-headed Flying-fox.

Year	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL
Total	0	0	$15,000	$15,000	0	$30,000

Action 4: Significantly reduce levels of deliberate Grey-headed Flying-fox destruction associated with commercial horticulture

Objectives 5, 6, 7, 10 and 11

Background. Grey-headed Flying-foxes cause damage to commercial fruit crops across all range States (Queensland, New South Wales and Victoria). The extent and severity of the damage varies from place to place and year to year. Licences to control Grey-headed Flying-foxes are currently issued to growers in New South Wales to mitigate commercial crop damage, within the bounds of a previously established national cull limit. A review of this practice is being undertaken in 2009 by an expert panel. Permits/licences to control Grey-headed Flying-foxes in commercial crops are not issued in Victoria. Queensland has in the past granted permits to shoot Grey-headed Flying-foxes subject to the national cull limit, but decided that it would grant no further permits from 1 September 2008. There is anecdotal evidence that Grey-headed Flying-foxes are illegally killed in the vicinity of commercial crops in all range States.

Population control by deliberate destruction is not considered to be an effective method of reducing crop damage in the long term and poses a threat to the recovery of the Grey-headed Flying-fox. The following set of actions is designed to assess the scale and pattern of crop damage and to develop locally appropriate solutions that will benefit both the commercial fruit growers and the Grey-headed Flying-fox.

Action 4.1: Identify the commercial fruit industries affected by the Grey-headed Flying-fox
Priority 1
Action has commenced

Summarise pre-existing information to describe the fruit industries affected by Grey-headed Flying-foxes. Information is to be gathered as required to provide an information base for other actions under this recovery plan; to improve knowledge of the industry by State and Australian Government agriculture and wildlife management agencies; to set production benchmarks for comparisons of management techniques for Grey-headed Flying-fox damage; and to inform industry groups.

Data collected in this project should include:

- locations of commercial fruit-growing operations (denatured to a scale acceptable to industry for privacy purposes)
- types and varieties of fruit grown
- area of land under cultivation to each variety of fruit
- area of each variety currently under full exclusion netting or other highly effective methods of protection
- area of each variety protected with other methods
- production losses attributed to flying-foxes
- other information as required by economic analysts, researchers, agencies, and industry groups.

Detailed results are to be provided to stakeholders as identified above; summary information is to be incorporated into actions under this recovery plan to inform and educate stakeholders and the general public.

Cost estimate: $575,000 for Actions 4.1, 4.3, 4.4 and 4.5

Year	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL
Total	*	*	*			

* = action implementation

Action 4.2: Develop and promote non-lethal measures to protect commercial crops from flying-fox damage
Priority 1
Action has commenced

In light of the patterns of crop damage and the threat posed to the Grey-headed Flying-fox population by legal and illegal deliberate destruction, as identified through the implementation of other actions in this recovery plan, State conservation and agriculture agencies will work with growers to develop and promote locally appropriate, non-lethal programs to protect commercial crops.

Appropriate programs should be developed in consultation with stakeholder groups. The approach taken may vary from State to State. Public support exists for instituting measures to support fruit growers in managing flying-foxes (Ballard 2004), and the approach is supported by both industry and conservation groups.

Economists at WWF Australia, working collaboratively on this issue with the NSW Farmers' Association and NSW Nature Conservation Council, have highlighted the need for further quantitative information to support the case for assistance. An important role of the recovery plan is to provide supporting information as required. Actions 4.1 to 4.8 address this issue.

In Queensland, assistance can be given to growers who meet the eligibility criteria to apply for Low Interest Productivity Loans that are available for the establishment and maintenance of orchard netting through the Queensland Rural Adjustment Authority's Development Loans scheme (see www.qraa.qld.gov.au). A similar scheme operates in NSW under the Rural Assistance Authority's Special Conservation Scheme for primary producers (see www.raa.nsw.gov.au).

The benefits to individual growers of such measures are apparent. However, there are also several public benefits in the form of increased food security, enhanced sustainability of various Australian fruit industries and more positive interactions between primary production and the rapidly increasing human population in rural and semi-rural areas. There are benefits to food security in Australia of maintaining geographically spread industries. In this case, there are benefits to protecting the viability of the range of commercial orchards in the southeast. Having industries that are widespread provides seasonal continuity of supply to consumers and reduces the impact of isolated events such as cyclones and hail storms.

Year	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL
Total	*	*	*	*	*	

* = action implementation

This action remains uncosted, as there are no data available upon which to estimate the cost.

Action 4.3: Systematically assess and document levels of flying-fox damage to the horticultural industry within the range of the Grey-headed Flying-fox
Priority 1
Action has commenced

Reliable information on the impact of flying-foxes on industry is required for these analyses. Current estimates of flying-fox damage to crops are based on anecdotal evidence; actual damage has not been measured or valued.

- Develop and trial methods to obtain reliable damage estimates.
- Estimate damage sustained by industries and the distribution of damage across fruit-growing areas.
- Conduct cost-benefit analyses of control methods (including density–damage relationships).

It is likely that crop-specific methods will need to be devised. Priority should be given to those crops and regional areas where incentive schemes are predicted to have the greatest conservation benefit (crops with low profit margins and high levels of damage by flying-foxes).

Cost estimate: $575,000 for Actions 4.1, 4.3, 4.4 and 4.5

Year	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL
Total	*	*	*			

* = action implementation

Action 4.4: Develop methods for rapid estimation of flying-fox damage to commercial fruit crops
Priority 1
Action has commenced

In order to monitor industry-wide levels and patterns of flying-fox damage, individual growers must be able to assess losses on their holdings. The methodologies developed in Action 4.3 to produce precise damage estimates are likely to be too labour-intensive to be of practical use to individual growers during harvest, and a method for rapid estimation is required.

- Develop a standard, practical sampling technique that will allow orchardists to accurately estimate damage to their crops at a sufficient level of precision to monitor trends. The sampling design should allow for differences in the frequency, timing and intensity of damage between regional areas and between different varieties of fruit to be measured.
- Conduct field trials to calibrate the method against more precise methods developed in Action 4.3.
- Provide training to growers so that methods are standardised within and across industries.
- Develop a centralised database, accessible by stakeholders, to which they can contribute their standardised data.
- Supervise the surveys and database, analyse results, make recommendations to improve successive samples, provide feedback to growers and write reports.
- Update sampling methods and designs to incorporate recommendations.

Cost estimate: $575,000 for Actions 4.1, 4.3, 4.4 and 4.5

Year	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL
Total	*	*	*			

* = action implementation

Action 4.5: Develop and implement a grower-based program to monitor trends in damage to fruit crops by flying-foxes
Priority 1

With active industry involvement, design and implement an annual sampling strategy to assess damage sustained to fruit crops from flying-foxes within the range of Grey-headed Flying-foxes, by using the rapid assessment technique developed under Action 4.4.

- Use results to monitor the performance of actions to reduce crop damage.
- Publish results in peer-reviewed journals.

Results to be made available to industry, State and Australian Government agriculture agencies, State and Australian Government wildlife management agencies, and those working to promote crop protection schemes; summary information is to be incorporated into actions under this recovery plan to inform and educate stakeholders and the general public.

Cost estimate: $575,000 for Actions 4.1, 4.3, 4.4 and 4.5

Year	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL
Total	*	*	*			

* = action implementation

Action 4.6: Develop methods for monitoring trends in nectar availability at a landscape scale
Priority 3

An indirect relationship between levels of crop damage and the availability of native food—primarily nectar production—has been hypothesised since studies of flying-fox damage to fruit industries were first conducted. However, methods for directly monitoring changes in nectar availability have not been developed. These are needed to explain and potentially predict trends in crop damage in the absence of crop protection, and to promote the importance of actions to protect and enhance foraging habitat that is productive in seasons critical to the horticultural industry (Actions 1 and 2).

- Review existing indices and initiatives to develop indices of nectar production suitable for monitoring trends at the geographic scales appropriate for assessing food availability for Grey-headed Flying-foxes.
- Develop an index of nectar flow for use in monitoring trends.
- Monitor trends at appropriate times and scales to investigate relationships between alternative food availability and estimates of crop damage from Actions 4.3, 4.4 and 4.5.
- Incorporate results as a covariate in analyses of trends in crop damage.

Year	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL
Total	0	0	$30,000	0	0	$30,000

Action 4.7: Collect biological information on flying-foxes deliberately destroyed in crops
Priority 2
Action has commenced

The impact of deliberate destruction of Grey-headed Flying-foxes in fruit crops on the population size and demographic structure of the species is unknown. This action aims to improve understanding of the impact by assessing trends in the species, sex, age and reproductive status of animals killed on crops.

This will be conducted by:

- securing the support of growers
- developing a repeatable sampling strategy for assessing trends, and collecting demographic information from populations at local camps and from animals killed by growers: species, sex, age, body condition and reproductive status (the sampling method must not require growers to handle or transport animals)
- providing feedback to growers and industry organisations and publishing results in peer-reviewed journals.

Additionally, this action may:

- compare the demographic characteristics of animals present in local camps with those of animals killed in crops
- assess differences between years, regional areas and type(s) of fruit grown
- assess covariate relationships with estimates of crop damage and estimates of population size in local camps
- provide data on camp estimates to Action 4.3 to help with damage–density estimates.

Summary information is to be incorporated into actions under this recovery plan to inform and educate stakeholders and the general public.

Year	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL
Total	$10,000	$10,000	$10,000	0	0	$30,000

Action 4.8: Assess damage to fruit crops in Victoria by the Grey-headed Flying-fox
Priority 1

The damage to Victorian fruit crops by flying-foxes has reportedly increased in association with the increase in occupation of camps in Melbourne and Geelong. Targeted effort is needed to better understand patterns of damage in this region; provide information to local fruit growers; inform Department of Sustainability and Environment field staff; and encourage uptake of non-lethal protection methods.

Year	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL
Total	$15,000	$	$	0	0	$15,000

Action 5: Provide information and advice to managers, community groups and members of the public that are involved with controversial flying-fox camps

Objectives 6, 7 and 11

Background. This action aims to provide active support to those involved with managing conflict with humans at flying-fox camps by providing summary information on the outcomes of past experiences; developing and providing management guidelines; developing and providing educational resources for affected communities; and conducting research to fill in important knowledge gaps.

Action 5.1: Review and evaluate recent management activities at flying-fox camps
Priority 2

- Engage an independent person with wildlife-management expertise to formally review management activities at flying-fox camps in recent years, including assessments of effectiveness, effort, cost and community responses. Practices being reviewed should include habitat management and public education, as well as direct wildlife management.
- Publish the results in a peer-reviewed journal.
- Produce a summary document, including case studies, for circulation to relevant agencies and affected people.

Summary information is to be incorporated into actions under this recovery plan to inform and educate stakeholders and the general public.

Year	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL
Total	$30,000	0	0	0	0	$30,000

Action 5.2: Develop guidelines to help land managers dealing with controversial flying-fox camps
Priority 2

Incorporate the outcomes from Action 5.1, the policies of State wildlife management agencies (e.g. Department of Environment and Climate Change 2007, Department of Sustainability and Environment 2005), the experiences of local government and further input from experienced individuals into guidelines for those charged with managing controversial flying-fox camps.

Guidelines may include:

- decision trees for assessing available management options
- material to help develop management plans for camps that are currently, or are likely to become, sites of conflict
- material to promote the use of management zones, where appropriate, to limit human interactions with roosting animals
- specific recommendations for managing camps identified as critical to the survival of the species.

Year	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL
Total	0	$30,000	0	0	0	$30,000

Action 5.3: Develop materials for public education and provide them to land managers and local community groups working with controversial flying-fox camps
Priority 2
Action has commenced

- Highlight the status of the species, the reasons for flying-fox presence in urban centres, the reasons for their decline, the management challenges that result, and the need to find a balance between protecting the species and minimising the impacts on the community.
- Make use of material produced under Action 6.1, as appropriate.
- Develop additional education resources as needed, including summaries of outcomes of Actions 5.1 and 5.4 in formats appropriate for public dissemination.

Cost estimate: see Action 6.1

Year	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL
Total	*	*	*	*	*	

* = action implementation

Action 5.4: Assess the impacts of Grey-headed Flying-fox camps on water quality
Priority 3
Action has commenced

Communities adjacent to camps often perceive that streams or water bodies may be adversely affected because of close proximity to a flying-fox camp.

- Monitor water quality in waterways adjacent to flying-fox camps and in roof-collected water at residences near camps.
- Publish results in a peer-reviewed journal.
- Provide the results to land managers and the community, and post on a website.

Year	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL
Total				$20,000		$20,000

Action 6: Produce and circulate educational resources to improve public attitudes toward Grey-headed Flying-foxes, promote the recovery program to the wider community and encourage participation in recovery actions

Objectives 6, 7 and 11

Background. The actions for recovery in this plan will take place across a large geographic area and have the potential to involve individuals and groups with a range of interests. Negative public attitudes toward the species act as an impediment to community support for the recovery process. Various studies of public attitudes toward Grey-headed Flying-foxes have concluded that programs of public education are the most appropriate means of improving attitudes and involving the community in conservation initiatives (Ford 2002, Lunney *et al.* 2002, Ballard 2004). It is important that the material presented to the public be accurate, credible and easy to access. Systems for circulating the material must have the capacity to reach a wide audience.

This action aims to provide educational resources of a uniform standard to support existing programs of public education (e.g. through community groups, State agencies and non-government organisations); to make information about Grey-headed Flying-foxes, the recovery plan and its progress available to the general public and people involved with the species; and to encourage community participation in appropriate recovery actions.

Action 6.1: Provide educational resources regarding the Grey-headed Flying-fox
Priority 1
Action has commenced

- Develop a comprehensive strategy of public education.
- Scrutinise the existing educational material relevant to Grey-headed Flying-foxes and secure permission for its distribution.
- Identify gaps and produce original material to fill the gaps.
- Establish central points of distribution in each range State.
- Provide the other actions under this recovery plan with comprehensive lists of the educational resources available under this action, and exchange resources.
- Produce regular newsletters to inform the public of the recovery plan, its progress, and opportunities for participation in actions.
- Create a website to promote the Grey-headed Flying-fox Recovery Plan and circulate information.
- Form cooperative alliances and exchange materials and information with other conservation and management programs.

Year	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL
Total	$18,000	$9,250	$9,250	$9,250	$9,250	$55,000

Action 6.2: Monitor public attitudes towards flying-foxes
Priority 2

- Conduct a survey of public attitudes to flying-foxes for comparison with the results of Ballard (2004).
- Expand the area surveyed to cover the range of Grey-headed Flying-foxes.

Year	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL
Total	0	0	0	0	$30,000	$30,000

Action 7: Monitor population trends for the Grey-headed Flying-fox

Objectives 7, 8 and 11

Background. A program is needed to monitor population trends and assess the effectiveness of recovery actions. To achieve these aims, the method for assessing population size must reliably detect relatively small shifts and repeat estimations must be made at sufficient frequency to provide an understanding of the natural fluctuations that occur (Pople 2003). Actions are needed to assess the precision of methods, determine confidence intervals, increase precision as required to meet aims, and collect data of known quality at regular intervals. It is necessary to either validate and refine the current technique or develop a different methodology. Any new methodology must be cost-effective, verifiable and repeatable, and it must attract the confidence of stakeholders.

Action 7.1: Review and improve methods used to assess population size for the Grey-headed Flying-fox
Priority 1
Action has commenced

The following work should be overseen or reviewed by a person with expertise in field and statistical methods for monitoring population trends:

- review recommendations made to improve population monitoring for Grey-headed Flying-foxes and implement key recommendations (e.g. Pople 2003)
- conduct field trials to improve precision of estimations of proportions of species in shared camps
- conduct field trials to improve precision of estimations of population size in camps not suited to exit counts
- explore alternative sampling methods (e.g. distance sampling; Clancy and Einoder 2004) and conduct field trials to assess such factors as precision, repeatability and feasibility.

Year	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL
Total	$25,000	$25,000	0	0	0	$50,000

Action 7.2: Monitor population trends for the Grey-headed Flying-fox
Priority 1

Conduct periodic range-wide assessments of population size of the Grey-headed Flying-fox, consistent with maintaining the expertise and enthusiasm of volunteers. The assessments should use the count method employed in previous years (Eby 2004) until such time as it can be updated to incorporate outcomes and recommendations from Action 7.1.

Results are to be provided to State and Australian Government wildlife agencies. Summary information is to be incorporated into actions under this recovery plan to inform and educate stakeholders and the general public.

Year	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL
Total	$51,750	0	$51,750	0	$51,500	$155,000

Action 8: Assess the impacts on Grey-headed Flying-foxes of electrocution on powerlines and entanglement in netting and barbed wire, and implement strategies to reduce these impacts

Objectives 6, 7, 9, 10 and 11

Background. The incidence of deaths or injuries to Grey-headed Flying-foxes from electrocution and entanglements is unknown. Actions are needed to increase public awareness, encourage reporting, develop methods for monitoring trends and identify and implement mitigation programs. This action requires the active involvement of community groups, such as animal rehabilitation organisations, and the general public.

Action 8.1: Assess the impacts on Grey-headed Flying-foxes of electrocution on powerlines and entanglement in netting and barbed wire, and implement strategies to reduce these impacts
Priority 3

- Review available information on the incidence of deaths and injuries to Grey-headed Flying-foxes from electrocution and entanglement.
- Review the remedial measures available to reduce impacts on wildlife of electrocution and entanglement, and promote those that are appropriate to Grey-headed Flying-foxes.
- Establish systems for direct reporting of electrocutions and entanglements by the public, with State-based collation and information sharing.
- Establish public awareness campaigns appropriate to the significance of the threat.
- Monitor trends as required.
- Form cooperative alliances with other conservation and management programs.

Summary information is to be incorporated into actions under this recovery plan to inform and educate stakeholders and the general public.

Year	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL
Total	$10,000	$2,500	$2,500	$2,500	$2,500	$20,000

Action 9: Oversee a program of research to improve knowledge of the demographics and population structure of the Grey-headed Flying-fox

Objectives 6, 7, 8, 9 and 10

Background. The list of proposed research topics below aims to clarify population structure in Grey-headed Flying-foxes and describe the demographics of the population. These topics are not covered in actions to reduce threats. However, a better understanding of each would greatly help with assessing the impacts of threats and developing efficient conservation strategies.

Action 9.1: Investigate the determinants of sedentary or transient status of Grey-headed Flying-foxes
Priority 3

A comparison of patterns of genetic relatedness, sex, age, etc., between sedentary and transient animals.

Cost estimate: $180,000 for Actions 9.1 to 9.3

Year	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL
Total			*	*	*	

* = action implementation

Action 9.2: Investigate between-year fidelity of individual Grey-headed Flying-foxes to seasonal camps
Priority 3

A telemetry and behavioural study of individuals in camps with seasonal (not continuous) patterns of occupation, allowing comparisons to be drawn with similar studies that have confirmed between-year fidelity of migratory animals to continuously occupied camps.

Cost estimate: $180,000 for Actions 9.1 to 9.3

Year	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL
Total			*	*	*	

* = action implementation

Action 9.3: Investigate genetic structure within Grey-headed Flying-fox camps
Priority 3

An investigation of levels of relatedness within and between members of adult groups, occupants of individual trees, etc.

Cost estimate: $180,000 for Actions 9.1 to 9.3

Year	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL
Total			*	*	*	

* = action implementation

Action 9.4: Investigate patterns of Grey-headed Flying-fox juvenile dispersal
Priority 3

A study of the dispersal behaviour and specific habitat requirements of juveniles.

Year	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL
Total	0	0	$22,500	$22,500	0	$45,000

Action 9.5: Investigate the age structure and longevity of Grey-headed Flying-foxes
Priority 2
Action has commenced

A project to support and build on the results of current research (Divljan *et al.* 2006) and provide baseline information for interpreting data collected in Actions 7.2 and 8.

Year	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL
Total	$10,000	$10,000	0	0	0	$20,000

Action 10: Maintain a National Recovery Team to oversee the implementation of the Grey-headed Flying-fox National Recovery Plan

Objectives 11 and 12

Action 10.1: Grey-headed Flying-fox National Recovery Team to undertake an annual review of the national recovery plan's implementation
Priority 1

With three range States for the Grey-headed Flying-fox, and with the species being listed nationally as a threatened species, implementation of the recovery program will require strong collaboration and coordination. A National Recovery Team will be established to manage and review the performance of the recovery plan (see Section 4.3). The National Recovery Team should include representatives of the government conservation agencies of Queensland, New South Wales and Victoria and Australia, representatives of primary stakeholders and at least one

person with suitable scientific expertise. An annual convenor of the recovery team should be assigned from the relevant State and Australian Government conservation agencies on a rotational basis. The National Recovery Team will meet annually to review the progress of the recovery plan's implementation against the criteria as set out in the plan and revise actions as necessary. A summary of the results of each review are to be reported to the relevant State and Australian Government conservation agencies, and to the general public. A written report evaluating performance against criteria will be provided to the Department of the Environment, Water, Heritage and the Arts after three and five years.

Year	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL
Total	$11,000	$11,000	$11,000	$11,000	$11,000	$55,000

5 Management practices

The recovery of Grey-headed Flying-foxes is primarily dependent on the protection and rehabilitation of foraging habitat and the expansion of forested areas that are productive during winter and spring. Management practices that destroy significant foraging habitats, or alter them to the extent that their productivity or suitability to the species is diminished, will have an adverse impact. In particular, clearance of key winter or spring habitats should be avoided, as should practices that reduce volumes of nectar available to Grey-headed Flying-foxes during those seasons. Important winter and spring habitats include vegetation communities that contain *Eucalyptus tereticornis*, *E. albens*, *E. crebra*, *E. fibrosa*, *E. melliodora*, *E. paniculata*, *E. pilularis*, *E. robusta*, *E. siderophloia*, *Banksia integrifolia*, *Castanospermum australe*, *Corymbia citriodora citriodora*, *C. eximia*, *C. maculata* (south from Nowra), *Grevillea robusta* and *Melaleuca quinquenervia*.

Management practices in fruit crops that expose Grey-headed Flying-foxes to deliberate destruction will also be detrimental to the species. In principle, the impact of these practices is curtailed by the current cull limit system that limits the licensed range-wide take. However, regulatory problems need to be addressed in New South Wales, Queensland and Victoria—particularly compliance with licence conditions and issues associated with unlicensed deliberate destruction.

Management practices to reduce conflict at controversial camps should be implemented. Every attempt should be made to resolve conflict through mediation and public education. Ideally, site management plans should be developed in conjunction with the community. Plans should include both long-term and short-term strategies for ameliorating conflict. Land management authorities should identify camps that are potential sites of conflict and initiate programs of public education to reduce the potential for future disputes. Where concerns have been raised, authorities should respond rapidly by providing advice and information to those involved. Attempts to remove flying-foxes from camps are not recommended, particularly at camps identified as critical to survival. In many cases, problems develop as a result of land-use planning that encourages inappropriate human development close to flying-fox camps. Where the option still exists, limitations should be placed on developments that can occur within approximately 300 m of flying-fox camps.

6 Duration and costs

6.1 Duration and costs

It is anticipated that the recovery process for the Grey-headed Flying-fox will take longer than the 5-year life of this recovery plan. Five years after the date of publication of the plan, its implementation and the effectiveness of its actions are to be reviewed, and its performance formally evaluated, by the Australian Government Department of the Environment, Water, Heritage and the Arts in conjunction with the Environmental Protection Agency (Qld), the Department of Environment, Climate Change and Water (NSW) and the Department of Sustainability and Environment (Vic). The timing and costs for each action proposed to support the recovery objectives are provided in Table 2. The total cost to implement this plan is estimated to be at least $1,715,000 over five years, plus as-yet-undetermined costs for developing and promoting measures to reduce the deliberate destruction of flying-foxes associated with commercial horticulture (Action 4.2).

6.2 Resource allocation

The actions proposed in this recovery plan build upon the Action Plan for Australian Bats (Environment Australia 1999), on expert knowledge of the species, and on research undertaken to date. At least 16 actions of this recovery plan are already under way.

The estimated cost of the plan comprises temporary project officer contracts, research/consultant contracts, funding contributions for student research projects (Honours, Masters and PhD) and in-kind contributions. Two actions cannot be fully costed—either they are contingent on the outcomes of other actions, or the details of the action and how it is to be implemented are yet to be determined. High-priority actions are to be initiated in the early phase of the plan's implementation, and often they span the full five years of the plan.

The efficient and effective use of resources has been considered when developing this recovery plan, and the recommended actions build on the knowledge obtained from previous and ongoing research projects, thus maximising the efficiency of the resources already committed to the conservation of the Grey-headed Flying-fox. The national cooperative approach between the Australian Government and the Queensland, New South Wales and Victorian State governments for the management and conservation of the Grey-headed Flying-fox continues, facilitating linkages that result in efficient resource use and avoid unnecessary duplications.

All actions have a cost, although many will be met through in-kind contributions or recurrent funding. The major costs of the plan are for research actions, a number of which are already under way. In-kind contributions will continue to be provided by the Australian Government Department of the Environment, Water, Heritage and the Arts in conjunction with Environmental Protection Agency (Qld), Department of Environment, Climate Change and Water (NSW) and the Department of Sustainability and Environment (Vic), building on the existing conservation programs. Additional, as-yet-unsecured, funds will be required to implement this recovery plan.

Actions to protect foraging habitat of the Grey-headed Flying-fox will confer benefits on both the numerous plant communities and the individual plant species with which this animal interacts, and on other nectar- and fruit-feeding bats, birds and mammals. Actions to protect the roosting habitat of the Grey-headed Flying-fox will additionally benefit other flying-fox species that share communal camps. Actions to reduce deliberate destruction of flying-foxes in commercial fruit crops via the introduction of alternate crop management techniques will also benefit other native species that damage crops. See Table 1 for the list of species to benefit from actions to recover the Grey-headed Flying-fox.

Table 2: Summary of actions

Actions for recovery are listed below, along with an indication of their priority and the years in which they should be carried out.
Priorities are set on a scale of 1 to 3, with 1 indicating the highest priority.
Years 1 to 5 represent years in the duration of the recovery plan.

Action	Priority	Year 1	Year 2	Year 3	Year 4	Year 5	Total cost
Action 1. Identify and protect foraging habitat critical to the survival of Grey-headed Flying-foxes across their range							
Action 1.1 Set priorities for protecting foraging habitat and generate maps of priority habitat for the Grey-headed Flying-fox	1	$30,000					$30,000
Action 1.2 Protect and enhance priority foraging habitat for the Grey-headed Flying-fox	1	$27,000	$9,500	$9,500	$9,500	$9,500	$65,000
Action 2. Enhance winter and spring foraging habitat for Grey-headed Flying-foxes							
Action 2.1 Increase the extent and viability of foraging habitat for the Grey-headed Flying-fox that is productive during winter and spring	1	$14,000	$14,000	$14,000	$14,000	$14,000	$70,000
Action 3. Identify, protect and enhance roosting habitat critical to the survival of Grey-headed Flying-foxes							
Action 3.1 Establish and maintain a range-wide database of Grey-headed Flying-fox camps	2	$15,000		$10,000		$10,000	$35,000
Action 3.2 Improve knowledge of Grey-headed Flying-fox camp locations, particularly in inland areas	2	$25,000		$10,000		$10,000	$45,000
Action 3.3 Protect roosting habitat critical to the survival of the Grey-headed Flying-fox	1	$14,000	$12,750	$12,750	$12,750	$12,750	$65,000
Action 3.4 Determine the characteristics of roosting habitat for the Grey-headed Flying-fox	2			$15,000	$15,000		$30,000

Action	Priority	Year 1	Year 2	Year 3	Year 4	Year 5	Total cost
Action 3.5 Enhance and sustain the vegetation in camps that are critical to the survival of the Grey-headed Flying-fox	2					$5,000	$5,000 Total cost undetermined: contingent on Action 3.4. Cost is for the dissemination of findings of Action 3.4.
Action 3.6 Investigate the interactions between the Grey-headed Flying-fox and the Black Flying-fox	2			$15,000	$15,000		$30,000
Action 4. Significantly reduce levels of deliberate Grey-headed Flying-fox destruction associated with commercial horticulture							
Action 4.1 Identify the commercial fruit industries affected by the Grey-headed Flying-fox	1	*	*	*			Funding from Actions 4.3 to 4.5
Action 4.2 Develop and promote non-lethal measures to protect commercial crops from flying-fox damage	1	*	*	*	*	*	Uncosted * denotes time of implementation
Action 4.3 Systematically assess and document levels of flying-fox damage to the horticultural industry within the range of the Grey-headed Flying-fox	1	*	*	*			$575,000 * Denotes time of implementation
Action 4.4 Develop methods for rapid estimation of flying-fox damage to commercial fruit crops	1	*	*	*			
Action 4.5 Develop and implement a grower-based program to monitor trends in damage to fruit crops by flying-foxes	1	*	*	*			
Action 4.6 Develop methods for monitoring trends in nectar availability at a landscape scale	3			$30,000			$30,000
Action 4.7 Collect biological information on flying-foxes deliberately destroyed in crops	2	$10,000	$10,000	$10,000			$30,000
Action 4.8 Assess damage to fruit crops in Victoria by the Grey-headed Flying-fox	1	$15,000					$15,000

Action	Priority	Year 1	Year 2	Year 3	Year 4	Year 5	Total cost
Action 5. Provide information and advice to managers, community groups and members of the public that are involved with controversial flying-fox camps							
Action 5.1 Review and evaluate recent management activities at flying-fox camps	2	$30,000					$30,000
Action 5.2 Develop guidelines to help land managers dealing with controversial flying-fox camps	2		$30,000				$30,000
Action 5.3 Develop materials for public education and provide them to land managers and local community groups working with controversial flying-fox camps	2						Funding from Action 6.1
Action 5.4 Assess the impacts of Grey-headed Flying-fox camps on water quality	3				$20,000		$20,000
Action 6. Produce and circulate educational resources to improve public attitudes toward Grey-headed Flying-foxes, promote the recovery program to the wider community, and encourage participation in recovery actions							
Action 6.1 Provide educational resources regarding the Grey-headed Flying-fox	1	$18,000	$9,250	$9,250	$9,250	$9,250	$55,000
Action 6.2 Monitor public attitudes towards flying-foxes	2					$30,000	$30,000
Action 7. Monitor population trends for the Grey-headed Flying-fox							
Action 7.1 Review and improve methods used to assess population size for the Grey-headed Flying-fox	1	$25,000	$25,000				$50,000
Action 7.2 Monitor population trends for the Grey-headed Flying-fox	1	$51,750		$51,750		$51,500	$155,000
Action 8. Assess the impacts on Grey-headed Flying-foxes of electrocution on powerlines and entanglement in netting and barbed wire, and implement strategies to reduce these impacts							
Action 8.1 Assess the impacts on Grey-headed Flying-foxes of electrocution on powerlines and entanglement in netting and barbed wire, and implement strategies to reduce these impacts	3	$10,000	$2,500	$2,500	$2,500	$2,500	$20,000

Action	Priority	Year 1	Year 2	Year 3	Year 4	Year 5	Total cost
Action 9. Oversee a program of research to improve knowledge of the demographics and population structure of the Grey-headed Flying-fox							
Action 9.1 Investigate the determinants of sedentary or transient status of Grey-headed Flying-foxes	3			*	*	*	$180,000 * Denotes time of implementation
Action 9.2 Investigate between-year fidelity of individual Grey-headed Flying-foxes to seasonal camps	3			*	*	*	
Action 9.3 Investigate genetic structure within Grey-headed Flying-fox camps	3			*	*	*	
Action 9.4 Investigate patterns of Grey-headed Flying-fox juvenile dispersal	3				$22,500	$22,500	$45,000
Action 9.5 Investigate the age structure and longevity of Grey-headed Flying-foxes	2	$10,000	$10,000				$20,000
Action 10. Maintain a National Recovery Team to oversee the implementation of the Grey-headed Flying-fox National Recovery Plan							
Action 10.1 Grey-headed Flying-fox National Recovery Team to undertake an annual review of the national recovery plan's implementation	1	$11,000	$11,000	$11,000	$11,000	$11,000	$55,000
TOTAL							$1,715,000

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