Source: © Matt Head

Manual

Fauna Sensitive Transport Infrastructure Delivery Chapter 10: Species profile – Flying-foxes

June 2024

Contents

Tables

Figures

1 Introduction

Flying-foxes are large bats that primarily feed on fruit, pollen, and nectar. Unlike microbats (Chapter 11), flying-foxes navigate visually (i.e. they do not echolocate), they roost communally in trees during the day and are significantly larger in size (up to 1 kg). Four species of flying-fox occur on mainland Australia, with all four species occurring in Queensland (Table 1.1). They are the black flying-fox (*Pteropus alecto*), grey-headed flying-fox (*Pteropus poliocephalus*), little-red flying-fox (*Pteropus scapulatus*) and spectacled flying-fox (*Pteropus conspicillatus*).

Flying-foxes have declined significantly in number since European settlement due to habitat loss, direct persecution, and, more recently, mortality due to heat stress. Consequently, the grey-headed flying-fox is listed under the *Environmental Protection and Biodiversity Conservation Act* 1999 (EPBC Act) and the spectacled flying-fox is listed under the *Queensland Nature Conservation Act* 1992 (NC Act) and under the EPBC Act (Table 1.1).

While flying-foxes occur across much of Queensland, they are largely concentrated in coastal and near coastal areas. However, flying-foxes are capable of large movements. For example, the little red flying-fox is nomadic and large numbers can move throughout Queensland as colonies follow seasonal flowering and fruiting resources[1]. Recent research has also demonstrated that the grey-headed flying-fox also migrates vast distances throughout its range (Adelaide to southern Queensland) in response to food resources[2]. Whilst the black flying-fox and spectacled flying-fox move relatively large distances for mammalian species, they do not appear to exhibit the same scale of spatial movements as the grey-headed flying-fox and little-red flying-fox.

1.1 Commonly encountered flying-fox species

Table 1.1 – Flying-fox species in Queensland likely to be encountered on transport projects

SCIENTIFIC NAME	COMMON NAME	DISTRIBUTION	HABITAT
Pteropus alecto	Black flying-fox	Species occurs within coastal and near coastal areas of northern Australia from Shark Bay in Western Australia to Lismore in New South Wales. They also occur through eastern Queensland, south to the Bellinger River in northern New South Wales.	Inhabit mangrove islands in river estuaries, Melaleuca swamps, eucalypt forests, urban forests, and rainforests.
Pteropus conspicillatus	Spectacled flying-fox	Almost entirely restricted to the Wet Tropics in northern Queensland, with a small population occasionally present on Cape York.	Species has been recorded roosting 6.5–16 kilometres from rainforest habitats. They feed largely on rainforest species. However, individuals will also regularly feed on non-rainforest species including *Eucalyptus* and *Corymbia* in tall open forests adjoining rainforest communities, tropical woodland, and savanna ecosystems.

[1] (Hall and Richards 2000)
[2] (Welbergen et al. 2020)

SCIENTIFIC NAME	COMMON NAME	DISTRIBUTION	HABITAT
Pteropus scapulatus	Little-red flying-fox	Widely distributed from northern and eastern Australia including Queensland, Northern Territory, Western Australia, New South Wales, and Victoria.	Inhabits rainforest and sclerophyll forests, extending inland to semi-arid areas.
Pteropus poliocephalus	Grey-headed flying-fox	Occurs within the coastal belt from Bundaberg in central Queensland to Adelaide in South Australia. The northern extent of the range has recently contracted southwards from Rockhampton and the southern extent has expanded to Adelaide. Local population size influenced by food availability. Areas in Brisbane are occupied permanently.	The species is a canopy-feeding frugivore and nectarivore which utilises rainforests, forests, woodlands, *Melaleuca* swamps and *Banksia* woodlands. Increasingly abundant in urban forests.

2 Ecology

2.1 Biology

Flying-foxes are active at night and during the day they sleep in groups known as camps or roosts, often numbering in the tens of thousands.

Flying-foxes are vital for ecosystem health and are key pollinators and seed dispersers of numerous native flora species, including eucalypts, melaleucas, banksias and rainforest species. The species group is critical for the ongoing health of Australia's Wet Tropics, Gondwana Rainforests, and woodlands throughout their geographic range. Flying-fox mobility, body size, territorial feeding activities, and social ecology result in the dissemination of pollen and seeds throughout the landscape. The ability to move vast distances among different habitat types allows seed and pollen to be transported across fragmented, degraded, and developed landscapes. Their ability to move up to 400 kilometres in one night is unique amongst Australian fauna[3].

Flying-fox populations are dynamic with a network of camps that increase and decrease in size throughout the year as they track food availability across the landscape[4]. Their diet traditionally included fruit, pollen, and nectar from a range of native forest types including mangroves, Eucalyptus forests, swamps, and rainforests. However, cultivated fruits in orchards and backyards, as well as native and exotic fruiting and flowering trees which are often planted in urban areas, are now common food resources. Therefore, both native and exotic feed species should be considered when assessing impacts to flying-foxes. The diet of each flying-fox species is summarised in Table 2.1.

The seasonal decline of food availability in one area drives migration and movement to another region with more abundant food. Flying-foxes are best thought of as a large continuous meta-population (a group of connected subpopulations) that utilises much of Queensland and eastern and northern Australia[5].

[3] (Hall and Richards 2000)
[4] (Welbergen et al. 2020)
[5] (Hall and Richards 2000)

Table 2.1 – Flying-fox diet description

SPECIES	DIET DESCRIPTION	
	Traditional Diet	**Non-Traditional Diet**
Black flying-fox[6]	Utilises nectar, pollen, and fruit, including *Eucalyptus* sp., *Corymbia* sp. *Lophostemon* sp., *Melaleuca* sp., native figs (*Ficus* sp.), Lilly-pilly's (*Syzygium* sp.), *Callistemons* sp., and *Grevillea* sp.	Cultivated fruit, planted native cultivars common in urban areas, and invasive plants such as Chinese celtis (*Celtis sinensis*), umbrella tree (*Schefflera actinophylla*), tipuana weed (*Tipuana tipu*) and cocos palm (*Syagrus romanzoffiana*).
Spectacled flying-fox[7]	Specialised frugivore—utilises native figs, blue quandongs (*Elaeocarpus angustifolius*), and lilly-pilly's.	Tropical cultivated fruits including mango, pawpaw, lychee, guava, banana, and custard apple. Often feeds on invasive wild tobacco (*Solanum mauritianum*).
Grey-headed flying-fox[8]	Utilises nectar, pollen, and fruit including *Eucalyptus* sp., *Corymbia* sp. *Lophostemon* sp., *Melaleuca* sp., native figs, lilly-pilly's, *Callistemons* sp., and *Grevillea* sp.	Cultivated fruit including stone-fruit, mango, and banana. Native planted cultivars common in urban areas and invasive plants such as Chinese celtis, umbrella tree, tipuana weed, and cocos palm.
Little red flying-fox[9]	Almost entirely nectivorous, feeding primarily on *Eucalyptus* sp., *Corymbia* sp. *Lophostemon* sp., *Melaleuca* sp., *Grevillea* sp. and *Bauhinia* sp. Fruit forms a small part of the diet and primarily consists of native figs.	Native planted cultivars including but not limited to golden penda (*Xanthostemon chrysanthus*).

2.2 Behaviour

Flying-foxes are capable of moving large distances. On a nightly basis, flying-foxes routinely travel up to 30–50 kilometres from their camp to feed and they can travel a few hundred kilometres per night when moving between camps. Over the course of the year, individual little-red flying-foxes can travel up to 3782–6073 kilometres, compared to 2268–2564 kilometres per year for grey-headed flying-foxes and up to 1887 kilometres per year for black flying-foxes[10].

The types of large-scale movements undertaken also varies among the species. For example, little-red flying-foxes are typically nomadic, tracking available resources across large spatial scales. The grey-headed flying-fox is typically more predictable, with a southward movement towards New South Wales and Victoria in spring and summer, and an increased use of coastal forests of South East Queensland in winter[11]. However, large seasonal events, such as mass flowering or fruiting events or failures, can disrupt typical behaviours and result in large influxes of animals into discrete areas. A large food shortage in northern New South Wales and southern Queensland resulted in the establishment of a temporary grey-headed flying-fox camp near Tarcutta in south-western New South Wales in 2010. Unfortunately, this coincided with the construction of the Hume Highway and disrupted construction for a short period of time before the colony naturally moved away.

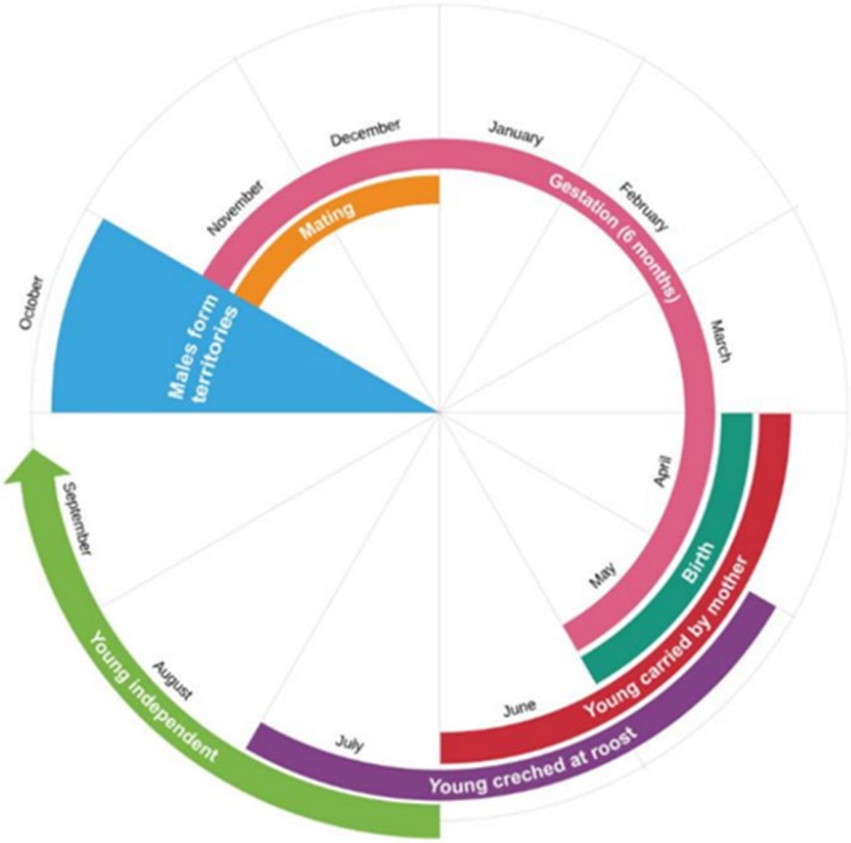
[6] (Markus and Hall 2004)
[7] (Richards 1990)
[8] (Eby 1998)
[9] (Bradford et al. 2022)
[10] (Welbergen et al. 2020)
[11] (Eby 1991, Parry-Jones and Augee 1992, Welbergen et al. 2020)

Female and male flying-foxes generally become sexually mature in their second and third fyear, respectively, and females typically give birth to a single pup each year, resulting in low population growth rates. The reproductive cycle is identical for black flying-fox, spectacled flying-fox, and grey-headed flying-fox (Figure 2.2(a)), and off-set by 6-months for little-red flying-fox (Figure 2.2(b))[12].

Young flying-foxes are carried by the mother for the first three to four weeks whilst she feeds, after which they are left in creche groups with other young at the camp whilst the mothers forage. A young flying-fox can fly at approximately three months of age at which time they begin leaving the camp for short flights. Independent young roost nearby to their mothers for approximately four months and the maternal bond can be extremely strong, with some bonds known to persist up to six years[13].

Flying-foxes are especially vulnerable to the impacts of disturbance (e.g. construction activities close to camps) during late pregnancy, while young are dependent on mothers and before the young become strong fliers. Disturbance during these times can lead to mass abortion events or mothers abandoning their young before they are able to fly and forage independently. These high-risk time periods are highlighted in Figure 2.2(a) and Figure 2.2(b).

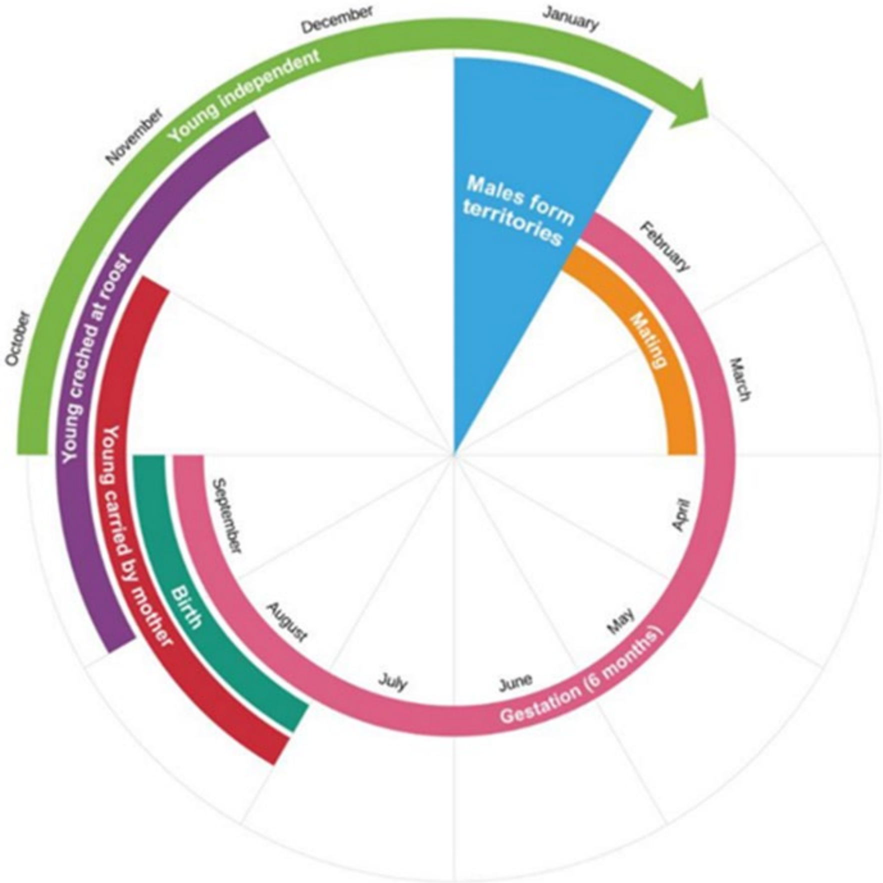
Figure 2.2(a) – Reproductive life-cycle of the black, grey-headed, and spectacled flying-fox and when they are sensitive to disturbance



Source: (DES 2020b)

[12] (Hall and Richards 2000)
[13] (Hall and Richards 2000)

Figure 2.2(b) – Reproductive life-cycle of the little red flying-fox, and when they are sensitive to disturbance



Source: (DES 2020b)

The risk categories in Figure 2.2(a) and Figure 2.2(b) should only be used as a guide, as some flying-fox camps do not contain breeding females and environmental or climatic factors may affect the timing of reproductive behaviour by several weeks or months. A flying-fox expert should be consulted when a proposed project or other works may impact on a flying-fox camp.

2.3 Habitat

The two critical habitats for flying-foxes are:

- The many camps or roosts where they congregate and sleep during the day.
- Their feeding areas which include 'natural' woodland and forest as well as trees occurring in largely cleared and developed areas, ranging from urban centres to agricultural areas.

Flying-fox camps occur in a range of wooded habitats and are typically located close to water and food sources. Camps can occur in a wide range of settings including remnant and regrowth bushland, formal parks and botanic gardens, scattered trees, and swampy areas. Increasingly, many camps are within cities and towns, ranging from city centres through to the urban-rural fringe. The trees forming the roost can range in height from low mangroves to tall trees and can include both native and introduced species. The important thing to be aware of is that flying-fox camps can potentially occur almost anywhere where trees provide structure for them to hang. No matter where they occur, camps are critically important places and support breeding, rearing of young, provision of shelter, and locations for information exchange.

All known flying-fox camps for grey-headed flying-fox and spectacled flying-fox are mapped in the National Flying-fox monitoring viewer. There are hundreds of camps across Australia, and they vary in size and pattern of occupation. The number of flying-foxes utilising a camp can range from a handful of individuals to many tens of thousands, occasionally reaching hundreds of thousands. Some camps are permanently occupied year-round while others are utilised seasonally, occasionally, or historically. The importance of a specific camp is determined by its size, presence of breeding females, and duration of use. Specifically, a 'nationally important' camp for grey-headed flying-fox is defined by the Commonwealth Government as camps that have:

- Contained greater than 10,000 grey-headed flying-fox in more than one year in the last 10 years, or
- Have been occupied by more than 2500 grey-headed flying-fox permanently or seasonally every year for the last 10 years.

Flying-foxes leave their camp at dusk to feed on nectar and fruit from a wide range of native and introduced species of trees. These food sources are distributed from the centre of cities and towns to large tracts of intact forest and woodland. As outlined in Table 2.1, diets vary among species and thus the definition and significance of important foraging habitat varies accordingly. For example, the spectacled flying-fox relies on tropical rainforest in far north-eastern Queensland, while the grey-headed flying-fox feed on eucalypts and other vegetation types across eastern Australia.

3 Direct impacts

3.1 Wildlife-vehicle collision

Flying-foxes can be subject to high rates of wildlife-vehicle collision (WVC) despite the fact that they can fly and are highly mobile. For example, nine grey-headed flying-fox were found dead on the side of three major roads during a 12-week survey period in north eastern New South Wales[14]. In far north Queensland, bat rescue groups recorded 24 spectacled flying-fox that had died due to WVC or had injuries consistent with WVC that led to euthanasia between September 2021 and February 2022[15]. Furthermore, between 2011–2016, at least 266 flying-foxes with WVC injuries were reported by New South Wales wildlife rehabilitation groups, along with a further 759 unspecified collisions, many of which probably included WVC[16].

Higher rates of flying-fox-vehicle collision are often associated with foraging or water resources and camps occurring adjacent to high traffic areas (Figure 3.1). The rates of WVC also varies seasonally, such as when roadside trees are fruiting or flowering. Rates of WVC are also likely higher at times when flying-foxes are experiencing food shortages because they are weaker and more likely to fly lower and feed on roadside trees and shrubs (Figure 3.1)[17]. Inexperienced young who are still learning

[14] (Taylor and Goldingay 2004)
[15] (Mclean 2022)
[16] (Mo et al. 2021)
[17] (Eby 2013)

to fly or mothers with dependent young who have reduced flying ability also have a higher likelihood of WVC[18].

It is important to note that the reported rates of flying-fox injury and mortality from WVC are certainly an underestimate because flying-foxes may be thrown significant distances from the road. In addition, carcases on the side of the road may be difficult to detect (Figure 3.1) and those on the road itself are likely to be quickly rendered unidentifiable.

Figure 3.1 – Multiple dead grey-headed flying-foxes adjacent to a highway and foraging habitat from afar (left) and up close (right)

Source: © Keely Boyd, Hunter Wildlife Rescue.

3.2 Habitat loss and modification

A primary threat to flying-foxes is the loss of roosting and foraging habitat. Flying-foxes require a continuous supply of food year-round and different areas, often many hundreds of kilometres apart, provide food at different times of year. The loss of foraging habitat is an ongoing threat to both grey-headed flying-fox and spectacled flying-fox[19]. The clearing of winter flowering and fruiting tree species is a particular threat to grey-headed flying-fox because this is a period of natural food shortages. These shortages are exacerbated because a large proportion of the winter foraging habitats are located on the coastal lowlands of South East Queensland and northern New South Wales, where human development and infrastructure is increasing. There is strong evidence that lack of suitable foraging sources during critical periods in the reproductive cycle is associated with rapid weight loss, poor reproductive success, and high rates of mortality for flying-foxes. Furthermore, a lack of suitable and safe foraging habitat in the wider landscape increases the likelihood of flying-fox WVC caused by foraging adjacent to roads[20].

The Wet Tropics World Heritage Area has provided protection of spectacled flying-fox foraging habitat. However, key foraging resources are also found outside the World Heritage Area where land clearing still occurs for development in coastal and near coastal regions and plateaus in the Wet Tropics[21].

[18] (Gorecki 2017)
[19] (Eby 2006, DCCEEW 2019)
[20] (Eby 1999, Collins 2000, Parry-Jones and Augee 2001)
[21] (DCCEEW 2019)

3.3 Noise and light pollution

Noise and light pollution during the construction and operation of roads and railways can significantly disturb flying-foxes, particularly when these impacts are adjacent to their camps. This sensitivity explains why the most common methods to disperse flying-fox camps involve repeated exposure to loud noise and bright lights which causes camp abandonment[22]. Subsequently, the impact of noise and lights at dawn and dusk, particularly during construction, is an important consideration.

However, many existing flying-fox camps occur in urban areas that are adjacent or nearby to roads, railways and other areas that contain high levels of disturbance, primarily noise and light pollution. Therefore, many flying-fox camps can persist in areas that have consistent low-levels of disturbance that the flying-foxes have become habituated to.

A recent review summarised the conditions and outcomes of six construction projects conducted near flying-fox camps (Table 3.3). Four camps were abandoned during construction and were not re-established. One camp re-stablished after being abandoned for approximately 20 years and the final camp persisted during construction. However, it is recognised that whilst significant road construction occurred at the Kurnell camp, the timing of the abandonment was concurrent with lack of water due to severe drought. Therefore, it is possible that construction activities were not the main cause of abandonment at that site. The abandonment of the Slacks Creek camp was attributed to noise, light, and other disturbance during the construction of the Southeast Freeway[23].

Camp abandonment can cause significant stress and result in mortality of flying-foxes. Importantly, any new camps that establish as a result of the disturbance may be in unsuitable locations that cause significant conflict with the general public, adjacent land uses, and land managers, and should thus be avoided.

Table 3.3 – The conditions and outcomes of six flying-fox camps adjacent to construction projects

ROOST	PROJECT	WORKS	ROOST OCCUPANCY	APPROXIMATE DISTANCE TO ROOST	OUTCOME
Kempsey Crescent Head Road	Pacific Hwy (PH) Kempsey Bypass	Crushing and screening facility, bridge piling.	Seasonal with long history of use.	200 metres to crushing. 500 metres from piling.	Camp abandoned after two years of construction. Not re-established.
Moorland	PH Moorland to Herons Creek Upgrade	Widen to four lane dual carriageway.	Irregular / long history of use.	Abuts – some roost site removed.	Camp abandoned. Not re-established.
Kurnell	Sydney Desalination Plant	Construction of extensive plant, five kilometres pipeline, tunnelling, trenching.	Seasonal with long history of use.	240 metres to above ground works. 450 metres to below ground works.	Camp abandoned during construction. Coincided with drought and loss of water source at camp. Not re-established.

[22] (Roberts et al. 2021)
[23] (Richards 2004)

ROOST	PROJECT	WORKS	ROOST OCCUPANCY	APPROXIMATE DISTANCE TO ROOST	OUTCOME
Slacks Creek	Southeast Freeway	Construction of dual carriageway and interchange bridge.	Continuous with long history of use.	175 metres to highway. 200 metres to bridge.	Camp abandoned during construction. Re-established after 20 years.
Tarcutta	Hume Hwy Tarcutta Bypass	Construction of four lane dual carriageway and bridge.	Temporary (food shortage).	230 metres to highway. 250 metres to bridge.	Camp abandoned during construction. Not re-established.
Campbelltown	Access Road	Construction of two-lane road, bridge piling.	Seasonal. New roost.	80 metres to road. 300 metres to bridge.	Camp remained through construction.

Source: (Gorecki et al. 2017)

3.4 Entanglement and electrocution

Flying-foxes are prone to entanglement with barbed-wire fencing and to electrocution on powerlines, resulting in injuries that generally lead to death or can cause pregnant females to abort young[24]. These impacts are exacerbated when lactating females are entangled, resulting in the death of dependant young left at the camp[25]. High rates of electrocution can also occur where wires are located adjacent to camps or pass through fruiting and flowering trees where flying-foxes feed. Wildlife carers in New South Wales reported 1730 individual flying-foxes electrocuted on overhead powerlines between 2011–2016, with the majority being grey-headed flying-foxes (Figure 3.4(c))[26].

Whilst barbed wire is frequently considered necessary for security purposes or containing stock, it is often used without consideration for wildlife. Figure 3.4(a) shows security fencing where panels have been applied to inhibit fauna movement but the top barbed wire has not been removed.

Due to disease risk, all rescues of flying-foxes from electrocutions and entanglement require trained and vaccinated personnel. In addition, the removal of flying-foxes and other wildlife from powerlines must be undertaken by energy providers (e.g. Energex) using elevated work platforms (Figure 3.4(d)).

[24] (Halpin et al. 1999, van der Ree 1999)
[25] (Gorecki 2017)
[26] (Mo et al. 2021)

Figure 3.4(a) – Combined security and koala-exclusion fencing with barbed wire at Dholes Rocks Road in Brisbane is a risk to flying-foxes, birds and gliders

Source: © Jasmine Vink, Arup 2022

Figure 3.4(b) – Entanglement of little-red flying-fox on barbed wire fence

Source: © Jasmine Vink, BCRQ 2022

Figure 3.4(c) – Flying-fox electrocution that led to euthanasia

Source: © Jasmine Vink, BCRQ 2022

Figure 3.4(d) – Energy provider removing injured flying-fox

Source: © Jasmine Vink, BCRQ 2022

4 Indirect impacts

4.1 Habitat degradation due to weed invasion

The construction and operation of transport infrastructure can exacerbate the spread of weeds and alter the structure and species composition of the vegetation through changes in the amount of sunlight and water availability. These changes can result in the establishment and growth of weeds and other species of plants that can reduce habitat quality and availability of foraging resources for flying-foxes.

4.2 Impacts to surface water and groundwater

The construction of transport infrastructure can change hydrological regimes by decreasing or increasing ground and surface water, potentially altering the microclimate of nearby camps. The availability of free-standing water for drinking, as well as for its cooling affect at the camp through evapotranspiration, is a critical environmental characteristic of camps[27] and changes to these may result in camp abandonment[28]. The importance of appropriate water regimes is likely to increase in the future as the frequency and severity of extreme heat events increases due to climate change[29]. Changes to the hydrological cycle may also affect tree health and survival, with follow-on impacts for flying-foxes at the camp.

5 Codes of Practice and Guidelines

The following guidelines and codes of practice have been developed to provide proponents with strategies to avoid, minimise, and mitigate impacts to flying-foxes. All these strategies should be followed to ensure all potential impacts are identified and managed accordingly:

- *Flying-fox Roost Management Guideline* – Queensland[30]
  - Assist decision-making regarding management options at flying-fox roosts.
  - Maximise the efficiency of various management actions at flying-fox roosts.
  - Minimise the likelihood of management actions at flying-fox roosts causing harm to flying-foxes.
- *Low impact activities affecting flying-fox roosts – Code of Practice, Nature Conservation Act 1992* (Low Impact Flying-fox CoP)[31]
  - Defines what low impact activities affecting flying-foxes are and how low impact activities may be undertaken at, or near, a flying-fox roost within Queensland.
- *Ecological sustainable management of flying-fox roosts – Code of Practice, Nature Conservation Act 1992* (Flying-fox CoP)[32]
  - Ensures that the likelihood of management actions resulting in harm to flying-foxes is minimised, and all appropriate welfare standards are upheld. The CoP provides guidance on activities which may destroy a flying-fox roost or disturb or disperse flying-foxes away from a camp.
- *Referral guideline for management actions in Grey-headed and Spectacled Flying-fox camps – EPBC Act Policy Statement* (Flying-fox Referral Guidelines)[33]
  - Assists proponents in determining whether a proposed action at a flying-fox camp is likely to have a significant impact on grey-headed flying-fox or spectacled flying-fox, and whether that proposed action requires referral to the Department for assessment in accordance with the EPBC Act.

[27] (Snoyman and Brown 2011)
[28] (Gorecki 2017)
[29] (Welbergen et al. 2020)
[30] (DEHP 2013)
[31] (DES 2020c)
[32] (DES 2020a)
[33] (Commonwealth of Australia 2015)

6 Avoidance and minimisation

The highest priority during project planning should be to avoid and minimise impacts to flying-foxes, where possible, including:

- Not clearing foraging or roosting habitat, especially winter foraging habitat.
- Not constructing roads and railways over or near riparian habitat that flying-foxes may feed or roost in.
- Minimising the amount of riparian vegetation and land impacted.
- Minimising the width of roads and railways to reduce clearing impacts.

Use the National Flying-fox monitoring viewer to identify potential camps. Ensure that historical data is also viewed as camps can be unoccupied for variable lengths of time (months to years) and may still be important roosting habitat even if the camp is unoccupied at the time of the investigations.

New flying-fox camps can also be established in unexpected locations at any time due to seasonal fluctuations in food availability across the geographic range of the species. While a low-likelihood of occurrence, construction teams should be aware of such an occurrence and respond accordingly. For example, a temporary grey-headed flying-fox camp was established along the Hume Freeway Bypass of the township of Tarcutta, New South Wales in 2010, during a long and widespread food shortage. Construction was temporarily halted and flying-fox specialists were consulted to determine which activities were compatible with the presence of the threatened grey-headed flying-fox. The camp naturally disbanded soon after arrival and construction continued as per normal.

7 Mitigation

7.1 Fencing

The risk of entanglement and death of flying-foxes (as well as birds and gliders) on barbed wire fencing can be eliminated by not installing barbed-wire and removing any existing barbed-wire fences. Where barbed wire fencing is required to control stock, or for security reasons, the following should be considered to reduce the risk of entanglement:

- Use plain wire on the top strand which is where the majority of entanglements occur, especially in high-risk locations, such within flight paths or near camps, or within high-quality flying-fox foraging habitat.
- Install reflective disks at approximately one metre intervals or UV stabilised tape (i.e. electric fence tape) on the top strand which increases the detectability of the barbed wire and allows flying-foxes and other at-risk species to avoid collision (Figure 7.1).

Figure 7.1 – Reflective disks on barbed wire fencing may increase the visibility of the fence to flying-foxes and reduce entanglements

Source: © Jasmine Vink, BCRQ, 2021

7.2 Landscape planting

Flying-foxes are more likely to collide with vehicles when:

- Flying-foxes are weaker from seasonal food shortages and are more likely to fly lower near roads and feed on roadside vegetation.
- Roadsides and centre medians contain vegetation on which flying-foxes feed, especially species that fruit or flower prolifically.

Where possible, roadsides and medians of high-speed and high-volume roads should not be planted with trees and shrubs that are flying-fox food sources. Priority tree species to avoid are detailed in Table 7.2.

Table 7.2 – Priority plant species, including all cultivars, to avoid planting along roads and railways

SPECIES NAME	COMMON NAME	SPECIES NAME	COMMON NAME
Banksia sp.	-	*Eucalyptus sp.*	-
Buckinghamia celsissima	Ivory curl	*Ficus sp.*	Figs
Callistemon/Melaleuca sp.	Bottlebrushes	*Grevillea sp.*	Spider flowers
Corymbia sp.	-	*Lophostemon sp.*	-
Cupaniopsis sp.	Tuckeroo	*Xanthostemon chrysanthus*	Golden penda
Elaeocarpus sp.	-		

8 Construction

8.1 Timing of construction activities

When clearing of roosting habitat or works near flying-fox camps is unavoidable, it should be undertaken outside of high and moderate risk times in the breeding cycle (Figure 2.2(a) and Figure 2.2(b)). For example, the Warrell Creek to Nambucca Heads Upgrade of the Pacific Highway cleared sections of Swamp Sclerophyll Forest which contained an established flying-fox camp. Vegetation clearing was only permitted when the flying-fox camp was empty or near-empty due to seasonal migration out of the area[34]. Monitoring of flying-fox camps that are near to projects should ideally be undertaken monthly for a few years prior to works commencing to inform the timing of works to minimise impacts. Standards relevant to timing activities as per the Flying-fox Referral Guidelines are detailed in Table 8.2.

8.2 Exclusion zones and buffers

The risk of direct and indirect impacts to flying-foxes can be mitigated by identifying and delineating flying-fox foraging and roosting habitat with appropriate fencing or other techniques[35].

Buffers should also be used between habitat and construction activities. The buffer distance between occupied flying-fox camps and major construction activities (e.g. vegetation clearing, earthworks, bridgeworks, and pavement construction) should be 300–500 metres. Construction activities can occur within the buffer zone when the camp is unoccupied, occupied at very low numbers, or during the low-risk times of year. Low impact activities (e.g. hand weeding, surveying, camp monitoring, critical incidence responses) that do not disturb roosting grey-headed flying-fox can occur at any time within the buffer zone.

Fortnightly monitoring of the number of flying-foxes within the camp should be undertaken during construction to determine the status of the camp and when construction within the buffer zone is permitted.

Additional mitigation requirements are described in Table 8.2.

Table 8.2 – Mitigation standards to be applied to all flying-fox camps[36]

STANDARD	DESCRIPTION
Timing of activities	The action must not occur if the camp contains females that are in the late stages of pregnancy or have dependant young that cannot fly on their own.
	The action must not occur during or immediately after climatic extremes (heat stress event or cyclone event) or during a period of significant food stress.
	The action must be supervised by a person with knowledge and experience relevant to the management of flying-foxes and their habitat who can identify dependent young and is aware of climatic extremes and food stress events. This person must assess the relevant conditions and advise the proponent whether the activity can go ahead consistent with these standards.

[34] (Gorecki 2017)
[35] (Gorecki 2017)
[36] (DOE 2015)

STANDARD	DESCRIPTION
Exclusion zones and buffers	Trees are not felled, lopped, or have large branches removed when flying-foxes are in or near to a tree and likely to be harmed.
	The action must not involve the clearing of all vegetation supporting a nationally-important flying-fox camp. Sufficient vegetation must be retained to support the maximum number of flying-foxes ever recorded in the camp of interest.

8.3 Flying-fox dispersal

Camp dispersal may be required when a road or railway project passes through a flying-fox camp and there are no feasible options for avoidance. Dispersal is required to move the flying-foxes prior to clearing to ensure there are no injuries or fatalities due to interactions with plant and other equipment. Camp dispersals should be avoided and undertaken as a last resort because the flying-foxes may establish new camps in other unsuitable locations[37]. Where possible, construction activities should be timed to occur when the camp is unoccupied, occupied by few flying-foxes, or at low-risk times of the year and the camp allowed to persist at the site. Specific approvals must be obtained prior to undertaking a relocation and there may be strict controls on timing and methods that must be adhered to.

9 Maintenance and operation

Maintenance and operation activities can impact flying-foxes through activities that disturb flying-fox camps and/or affect the availability of feeding habitat through tree removal. Flying-fox camps that occur next to roads and railways should be registered as environmental assets and managed following the principles and guidelines outlined in this chapter. All fruiting and flowering trees along transport infrastructure are potentially foraging resources for flying-foxes and the impact of their lopping or removal during maintenance and operation activities on flying-foxes should be assessed before undertaken.

[37] (Roberts and Eby 2013)

References

Bradford, M., K. Venz, K. Bell, L. Hogan, G. Smith, P. Eby, T. Eyre, A. McKeown, E. Vanderduys, S. MacDonald, and D. Westcott. 2022. *The diet of a specialist nectarivore in Australia: The little red flying-fox (Pteropus scapulatus, Pteropodidae)*. Austral Ecology 47:619-628.

Collins, L. 2000. *Impact of periods of food shortage on the body weight of Grey-headed Flying-foxes*. Pages 99-101 in Proceedings of a Workshop to Assess the Status of the Grey-headed Flying-fox in New South Wales.

Commonwealth of Australia. 2015. *Referral guideline for management actions in Grey-headed and Spectacled Flying-fox camps —EPBC Act Policy Statement*.in D. o. t. Environment, editor.

DCCEEW. 2019. Conservation advice. *Pteropus conspicillatus spectacled flying-fox*.in E. Department of Climate Change, the Environment and Water, editor.

DEHP. 2013. *Flying-fox Roost Management Guideline – Queensland*.in D. o. E. a. H. Protection, editor., Queensland.

DES. 2020a. *Ecological sustainable management of flying-fox roosts — Code of Practice, Nature Conservation Act 1992* in D. o. E. a. Science, editor., Queensland.

DES. 2020b. *Flying-fox roost management guideline*.in D. o. E. a. S. Wildlife and Threatened Species Operations, editor. State of Queensland, Queensland.

DES. 2020c. *Low impact activities affecting flying-fox roosts — Code of Practice, Nature Conservation Act 1992*.in D. o. E. a. Science, editor., Queensland.

DOE. 2015. *Referral guideline for management actions in grey-headed and spectacled flying-fox camps*. EPBC Act Policy Statement., Department of Environment.

Eby. 2013. *A review of comparative assessment of alternative alignment options, Pacific Highway Upgrade, Warrell Creek to Nambucca Heads*.

Eby, P. 1991. *Seasonal movements of Grey-headed flying-foxes, Pteropus poliocephalus (Chiroptera: Pteropodidae), from two maternal camps in northern New South Wales*. Wildlife Research 18:547-559.

Eby, P. 1998. *An analysis of diet specialisation in frugivorous Pteropus poliocephalus (Megachiroptera) in Australian subtropical rainforest*. Australian Journal of Ecology 23:443-456.

Eby, P. 1999. *Low reproductive output in Grey-headed Flying-foxes associated with a short period of food scarcity*. Australasian Bat Society Newsletter 14:17-20.

Eby, P. 2006. *Draft National Recovery Plan for the Grey-headed Flying-fox Pteropus poliocephalus*. NSW Department of Environment and Conservation, Sydney.

Gorecki, V., R. Vazey, C. Thomson, and P. Eby. 2017. *Warrell Creek to Urunga Upgrade of the Pacific Highway*. Flying-fox Management Plan. SKM.

Gorecki, V., Vazey, R., Thomson, C., Eby, P. 2017. *Flying-fox Management Plan - Warrell Creek to Urunga Upgrade of the Pacific Highway*. Roads and Maritime Services.

Hall, L. S., and G. Richards. 2000. *Flying foxes: fruit and blossom bats of Australia*. UNSW Press.

Halpin, K., P. Young, H. Field, and J. Mackenzie. 1999. *Newly discovered viruses of flying foxes*. Veterinary Microbiology 68:83-87.

Markus, N., and L. Hall. 2004. *Foraging behaviour of the Black Flying-fox (Pteropus alecto) in the urban landscape of Brisbane, Queensland*. Wildlife Research 31:345-355.

Mclean, J. 2022. 2021-2022 *Flying Fox Mortality* Unpublished data Tolga Bat Hospital

Mo, M., M. Roache, R. Haering, and A. Kwok. 2021. *Using wildlife carer records to identify patterns in flying-fox rescues: a case study in New South Wales, Australia*. Pacific Conservation Biology 27:61-69.

Parry-Jones, K. A., and M. L. Augee. 1992. *Movements of Grey-headed Flying Foxes (Pteropus poliocephalus) to and from a Colony Site on the Central Coast of New South Wales*. Wildlife Research 19:331-340.

Parry-Jones, K. A., and M. L. Augee. 2001. *Factors affecting the occupation of a colony site in Sydney, New South Wales by the Grey-headed Flying-fox Pteropus poliocephalus (Pteropodidae)*. Austral Ecology 26:47-55.

Richards, G. 1990. *The spectacled flying-fox, Pteropus conspicillatus (Chiroptera: Pteropodidae), in north Queensland*. Diet, seed dispersal and feeding ecology. Australian Mammalogy 13:25-31.

Richards, G. 2004. *An assessment of flying-fox issues in relation to the Kempsey-Eungai Pacific highway upgrade*. Parsons Brinkerhoff.

Roberts, B., and P. Eby. 2013. *Review of past flying-fox dispersal actions between 1990-2013.3*.

Roberts, B. J., M. Mo, M. Roache, and P. Eby. 2021. *Review of dispersal attempts at flying-fox camps in Australia*. Australian Journal of Zoology.

Snoyman, S., and C. Brown. 2011. and C. Brown. 2011. *Microclimate preferences of the grey-headed flying fox (Pteropus poliocephalus) in the Sydney region*. Australian Journal Of Zoology 58:376-383.

Taylor, B. D., and R. L. Goldingay. 2004. *Wildlife road-kills on three major roads in north-eastern New South Wales*. Wildlife Research 31:83-91.

van der Ree, R. 1999. *Barbed wire fencing as a hazard for wildlife*. The Victorian Naturalist 116:210-217.

Welbergen, J. A., J. Meade, H. E. Field, D. Edson, L. McMichael, L. P. Shoo, J. Praszczalek, C. Smith, and J. M. Martin. 2020. *Extreme mobility of the world's largest flying mammals creates key challenges for management and conservation*. BMC Biology 18:101.