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COMMONWEALTH PARK GREY HEADED FLYING-FOX CAMP MANAGEMENT PLAN

FINAL November 2020

NATIONAL CAPITAL AUTHORITY

Executive summary

As a threatened species, the grey-headed flying-fox is protected under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. Flying-foxes are also protected in the Australian Capital Territory under the *Nature Conservation Strategy 2014*.

Flying-foxes appear to be roosting and foraging in urban areas more frequently. Commonwealth Park camp on the edge of Lake Burley Griffin is managed by the National Capital Authority. The National Capital Authority commissioned this camp management plan to provide guidance to park and event managers regarding operations and acceptable behaviours of user groups around the colony. Preparation of this plan has involved site assessment and consultation with National Capital Authority staff and key stakeholders.

This Plan provides guidance and risk mitigation strategies for three management sectors of the Park:

- Park management
- Tree management
- Event management.

Current and proposed users of Commonwealth Park should assess whether their activity requires management or mitigation to reduce direct or indirect impacts to the camp. Spring to summer is the highest risk period in the grey-headed flying-fox breeding cycle.

Mitigation and management measures applied should increase with each increasing level of risk (from routine camp maintenance to medium and high-risk activities). Mitigation methods include:

- modification of proposed activities (e.g. avoid, reduce)
- monitoring and adaptive management by flying-fox expert and reporting on results
- community and staff education
- appropriate personnel behaviour.

The National Capital Authority is committed to protecting the grey-headed flying-fox as a matter of national environmental significance and will to continue to promote their value to park personnel and patrons.

Acknowledgements

Ecosure acknowledges Peter Beutel (National Capital Authority (NCA)) for his assistance in developing this plan, and the NCA for the provision of mapping data. We also thank Jason Ferris and Tim McGrath (Department of Environment and Energy), Kathryn Tracy, Murray Evans (ACT Government), Lachlan Wood, Brad Hetharia, Carly Lowe, Duncan McLennan (NCA), Matt Reid (Citywide), Belinda Wilson (Australasian Bat Society), Marg Peachy, Denise Kay and Caroline Hennessy (ACT Wildlife) for their time and knowledge during the engagement process in the development of this Plan.

Acronyms and abbreviations

ABLV	Australian Bat Lyssavirus
ABS	Australasian Bat Society
ACT	Australian Capital Territory
COP	Code of Practice
Colony Area	The area of Commonwealth Park as identified in Figure 6
DAWE	Department of Agriculture, Water and Environment (Commonwealth)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
GHFF	grey-headed flying-fox (*Pteropus poliocephalus*)
the Guideline	Referral guideline for management actions in grey-headed and spectacled flying-fox camps 2015
ha	hectare
HeV	Hendra virus
HSE	Heat stress event
MNES	matter of national environmental significance
NCA	National Capital Authority
NC Act	*Nature Conservation Act 2014*
NFFMP	National Flying-fox Monitoring Program
NSW	New South Wales
OEH	Office of Environment and Heritage
the Park	Commonwealth Park
the Plan	this Flying-fox Camp Management Plan
PALM Act	Australian Capital Territory *(Planning and Land Management) Act 1988*
QLD	Queensland
TEC	Threatened ecological community
V	Vulnerable

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1 Introduction

The National Capital Authority (NCA) engaged Ecosure to prepare this camp management plan (the Plan) for the grey-headed flying-fox (*Pteropus poliocephalus*) (GHFF) camp at Commonwealth Park (the Park), Canberra. The park is a part of National Lands (Commonwealth owned) in the ACT and managed by the NCA.

The Park includes treed and garden areas, an outdoor stage (Stage 88), playground, barbeque facilities, ponds, bike paths and walking trails. A number of planted trees in the Park have heritage value. Over 40 events are held at Commonwealth Park each year. Stage 88 holds numerous concerts throughout the year and the park hosts many events including Floriade, an annual event since 1988.

1.1 Management intent

The objectives of the Plan are to identify acceptable operations within the Park that align with best practice principles for protecting GHFF and their habitat, and to provide guidance to Park and event managers regarding operations and acceptable behaviours of user groups around the colony. This Plan provides risk mitigation strategies for three management sectors of the Park:

- Park management
- Tree management
- Event management.

1.2 Site assessment

A literature review and site assessment of the camp was undertaken to understand:

- the camp extent
- impacts to the camp from public, operational or event use of the camp site
- any health risks to staff or public
- condition of and impacts to camp vegetation
- proximity of flying-foxes to residential areas or other sensitive sites
- potential for the camp to increase in number or relocate.

1.3 Stakeholders

Preparation of the Plan has involved consultation with NCA staff and key stakeholders in Table 1.

Table 1 Stakeholder groups for Commonwealth Park and flying-fox conservation

Flying-fox conservation	Park management	Tree management	Event management
NCA Estate Management	NCA Estate Management	NCA Tree Management	NCA Event Administration
ACT Wildlife	Citywide contractor	Arborists	Event organisers
Department of Environment & Energy	National Capital Exhibition	Park users	Event artists and retailers
Australasian Bat Society	The Deck (tenant)		Patrons
ACT Government	Canberra Visitor Centre		
Veterinarians able to treat flying-foxes	Park users		
Park users			

2 Legislation

The Australian Government and Australian Capital Territory (ACT) Government share planning responsibility in the ACT. A Conservation Agreement should be negotiated between NCA, Department of Agriculture, Water and Environment (DAWE) and the ACT Government with the development of the Grey-headed Flying-fox Native Species Conservation Plan.

2.1 Commonwealth

2.1.1 *Environment Protection and Biodiversity Conservation Act 1999*

The Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) provides protection for the environment, specifically 'matters of national environmental significance' (MNES). A referral to the Commonwealth DAWE is required under the EPBC Act for any action that is likely to significantly impact on an MNES.

MNES under the EPBC Act that relate to flying-foxes include nationally threatened species and ecological communities. The GHFF is listed as a vulnerable species under the EPBC Act, meaning it is an MNES. It is also considered to have a single national population. DAWE has developed the 'Referral guideline for management actions in grey-headed and spectacled flying-fox camps' (Department of the Environment [DoE] 2015) (the Guideline) to guide whether referral is required for actions pertaining to the GHFF.

The Guideline defines a nationally important GHFF camp as one that has either:

- contained ≥10,000 GHFF in more than one year in the last 10 years, or
- been occupied by more than 2,500 GHFF permanently or seasonally every year for the last 10 years.

Commonwealth Park camp does not currently meet the criteria for a nationally important camp (Figure 5 pp. 14), however it is often occupied by more than 2,500 GHFF and has the potential for a sudden influx of more than 10,000 GHFF (with a maximum to date of 8,190, see Section 4.2). For these reasons, and that the NCA is committed to best practice, management will align with standards outlined in the Guideline.

Threshold for referral

Based on current use of the Park and management intent for the camp, a significant impact to the GHFF population is unlikely, and referral is not likely to be required. Referral will be required if a significant impact to any other MNES is considered likely as a result of management actions outlined in the Plan. Self-assessable criteria are available in the Significant Impact Guidelines 1.1 (DoE 2013) to assist in determining whether a significant impact is likely; otherwise consultation with DAWE is required.

A 'significant impact' is an impact which is important, notable, or of consequence, having regard to its context or intensity. Whether or not an action is likely to have a significant impact

depends upon the sensitivity, value, and quality of the environment, which is impacted, and upon the intensity, duration, magnitude and geographic extent of the impacts.

Significant impact criteria for vulnerable species are outlined in the Significant Impact Guidelines 1.1 (DoE 2013:10).

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

- *lead to a long-term decrease in the size of an important population of a species*
- *reduce the area of occupancy of an important population*
- *fragment an existing important population into two or more populations*
- *adversely affect habitat critical to the survival of a species*
- *disrupt the breeding cycle of an important population*
- *modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline*
- *result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat*
- *introduce disease that may cause the species to decline, or*
- *interfere substantially with the recovery of the species.*

Due to the mobility of flying-foxes, this criteria applies to Nationally Important Camps. If Commonwealth Park were to become Nationally Important in the future, it would be pertinent to ensure the area of occupancy at this camp is protected, as well as mitigating against disruptions to the breeding cycle. If an activity was likely to be in contradiction to these criteria it would need to be referred.

The EPBC Act requires a permit for activities which may kill, injure or move a member of a list threatened species in or on a Commonwealth area, however exemptions may be sought from the Minister if the activity is in the national interest.

2.1.2 Australian Capital Territory *(Planning and Land Management) Act 1988* (PALM Act)

Under the PALM Act, the NCA functions are, but not limited to:

- prepare and administer the National Capital Plan
- manage and maintain assets including National Land as well as leases, licences and venues
- promote the attributes of Canberra that are of national significance.

The purpose of the National Capital Plan is to ensure that the Commonwealth's national capital interests in the Territory are fully protected, without otherwise involving the Commonwealth in matters that should be the prerogative of the Canberra community. The PALM Act states that

the National Capital Plan prevails over the Territory Plan and is legally binding in both the Act and the Commonwealth.

2.2 Territory

2.2.1 *Nature Conservation Act 2014*

The *Nature Conservation Act 2014* (NC Act) is the chief legislation for the protection of native plants and animals in the ACT and for the management of the conservation reserve network.

The Executive Director of Environment at the ACT Government Environment, Planning and Sustainable Development Directorate holds the Office of the Conservator of Flora and Fauna. The Conservator acts on issues that affect the conservation matters embodied in the NC Act. This relates to, in particular, protecting native plants and animals including the administration of a licensing system for the taking, keeping, selling, importing, exporting, disturbing, displaying and killing of native plants and animals; managing the nature reserve system; and protecting and conserving threatened species and ecological communities (ACT Govt 2018). The NC Act requires the Conservator of Flora and Fauna to prepare an action plan in response to each declaration of a threatened species, ecological community or threatening process.

A Controlled Native Species Management Plan for a native animal must be consistent with each approved code of practice and mandatory code of practice under the *Animal Welfare Act 1992* that applies to the animal.

Special protection status

Species that are listed as threatened under the ACT *Nature Conservation Act 2014*, or as threatened or migratory under the EPBC Act are given special protection status.

Special protection status increases the penalties for a range of offences given that the impact of activities undertaken without a licence are considered to cause more damage because the species is already threatened with extinction. There may also be species that are given special protection status under the EPBC Act, that are not considered threatened in the ACT. Those species may be managed through a Native Species Conservation Plan. An example is the Murray Cod, which is listed nationally as threatened and therefore has special protection status but is managed in the ACT (and other jurisdictions) for recreational fishing.

Special protection status is automatically given to a species once it is listed. An up to date list of the species with special protection status that are likely to occur in the ACT will be maintained on the EPD website.

Native Species Conservation Plans for protected species

Native Species Conservation Plans are a flexible management tool that can be applied to any native species that requires management. A Native Species Conservation Plan could be made for the GHFF. Action Plans are generally more appropriate for a species that is declining in the ACT.

Action Plans

Action Plans are required for all threatened species unless the Minister decides that an Action Plan is not required. A plan does not need to be prepared if the species is the subject of a native species conservation plan.

2.2.2 *Animal Welfare Act 1992*

The objects of this Act are to:

(a) promote and protect the welfare, safety and health of animals; and

(b) ensure the proper and humane care and management of animals; and

(c) reflect the community's expectation that people who keep or care for animals will ensure that they are properly treated.

2.3 Supplementary flying-fox legislation

Flying-foxes are widely distributed across several eastern Australian states, and as such should be considered a single national population. Flying-foxes are subject to a number of management frameworks across the country which have been considered for actions within the Plan including:

- Code of practice for ecologically sustainable management of flying-fox roosts (QLD)
- Code of practice for low impact activities affecting flying-fox roosts (QLD)
- Code of practice – ecologically sustainable lethal take of flying-foxes for crop protection (QLD)
- Flying-fox Roost Management Permits for private entities, as well as Councils wishing to manage flying-fox roosts located outside an Urban Flying-fox Management Area (QLD)
- Flying-fox Camp Management Policy 2015 (NSW)
- Flying-fox Camp Management Code of Practice 2018 under the Biodiversity Conservation Regulation 2017 (NSW).

3 Flying-fox ecology

All flying-foxes are nocturnal, roosting during the day in communal camps. These camps may range in number from a few to hundreds of thousands, with individual animals frequently moving between camps within their range. Typically, the abundance of resources within a 20-50-kilometre radius of a camp site will be a key determinant of the size of a camp (SEQ Catchments 2012). Therefore, flying-fox camps are generally temporary and seasonal, tightly tied to the flowering of their preferred food trees.

3.1 Flying-foxes in urban areas

Flying-foxes appear to be roosting and foraging in urban areas more frequently. During a study of national flying-fox camp occupation, almost three quarters of the 310 known GHFF camps (72%) were located in urban areas, 22% on agricultural land and only 4% in protected areas (Timmiss 2017). Furthermore, the number of camps increased with increasing human population densities (up to ~4000 people per km^2) (Timmiss 2017). There are many possible drivers for this urbanising trend, as summarised by Tait et al. (2014):

- loss of native habitat and urban expansion
- opportunities presented by year-round food availability from native and exotic species found in expanding urban areas
- disturbance events such as drought, fires, cyclones
- human disturbance or culling at non-urban camps or orchards
- urban effects on local climate
- refuge from predation
- movement advantages, e.g. ease of manoeuvring in flight due to the open nature of the habitat or ease of navigation due to landmarks and lighting.

As such it is likely that flying-foxes will continue to use Commonwealth Park in the long-term and could establish new camps in Canberra in the future.

3.2 Camp preferences

Little is known about flying-fox camp preferences; however, research indicates that apart from being in close proximity to food sources, flying-foxes choose to roost in vegetation with at least some of the following general characteristics (SEQ Catchments 2012):

- closed canopy >5m high
- dense vegetation with complex structure (upper, mid and understorey layers)
- within 500m of permanent water source
- within 50km of the coastline or at an elevation <65m above sea level

- level topography (<5° incline)
- greater than one hectare to accommodate and sustain large numbers of flying-foxes.

3.3 Grey-headed flying-fox

The GHFF (Figure 1) is found throughout eastern Australia, generally within 200 kilometres of the coast, from Finch Hatton in Queensland to Melbourne, Victoria (OEH 2015d). This species now ranges into South Australia and has been observed in Tasmania (DoE 2016a). It requires foraging resources and camp sites within rainforests, open forests, closed and open woodlands (including melaleuca swamps and banksia woodlands). This species is also found throughout urban and agricultural areas where food trees exist and will raid orchards at times, especially when other food is scarce (OEH 2015a).

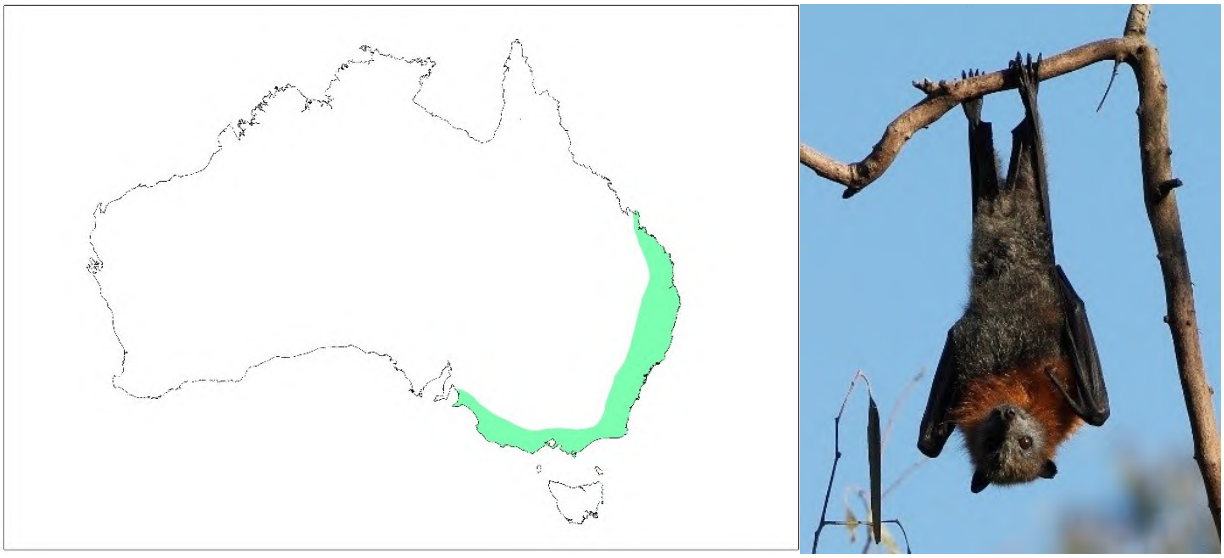

Figure 1 Grey-headed flying-fox indicative species distribution, adapted from OEH 2015a

There is evidence the GHFF population declined by up to 30% between 1989 and 2000 (Birt 2000; Richards 2000 cited in OEH 2011a). There is a wide range of ongoing threats to the survival of the GHFF, including habitat loss and degradation, deliberate destruction associated with the commercial horticulture industry, conflict with humans, infrastructure-related mortality (e.g. entanglement in barbed wire fencing and fruit netting, power line electrocution, etc.) and competition and hybridisation with the black flying-fox (*Pteropus alecto*) (DECCW 2009). For these reasons it is listed as vulnerable to extinction under NSW and federal legislation.

All the GHFF in Australia are regarded as one population that moves around freely within its entire national range (Webb & Tidemann 1996; DoE 2015). GHFF may travel up to 100 kilometres in a single night with a foraging radius of up to 50 kilometres from their camp (McConkey et al. 2012). They have been recorded travelling over 500 kilometres over 48 hours when moving from one camp to another (Roberts et al. 2012). GHFF generally show a high level of fidelity to camp sites, returning year after year to the same site, and have been recorded returning to the same branch of a particular tree (SEQ Catchments 2012). This may

be one of the reasons flying-foxes continue to return to small urban bushland blocks that may be remnants of historically-used larger tracts of vegetation.

The GHFF population has a generally annual southerly movement in spring and summer, with their return to the coastal forests of north-east NSW and south-east Queensland in winter (Ratcliffe 1932; Eby 1991; Parry-Jones & Augee 1992; Roberts et al. 2012). This results in large fluctuations in the number of GHFF in NSW, ranging from as few as 20% of the total population in winter up to around 75% of the total population in summer (Eby 2000). They are widespread throughout their range during summer, but in spring and winter are uncommon in the south. In autumn they occupy primarily coastal lowland camps and are uncommon inland and on the south coast of NSW (DECCW 2009).

3.3.1 Flying-fox breeding season

The mating season (March to April) represents the period of peak camp occupancy (Markus 2002). GHFF are born from September to November (Churchill 2008) after a six month gestation, although out of season breeding is common (Table 2). Young are highly dependent on their mother for food and thermoregulation. Young are suckled and carried by the mother until approximately four weeks of age (Markus & Blackshaw 2002). At this time, they are left at the camp during the night in a crèche until they begin foraging with their mother between January and March (Churchill 2008) and are usually weaned by six months of age. Young still rely on their mother for warmth and nutrition and are vulnerable during the crèching period because they are left at the camp during the night and cannot fly very well or very far. Sexual maturity is reached at two years of age with a life expectancy up to 20 years in the wild (Pierson & Rainey 1992).

Table 2 Indicative flying-fox reproductive cycle

Month	FF breeding
Jan	Creche period
Feb	Creche period
Mar	Peak conception
Apr	Peak conception
May	
Jun	
Jul	
Aug	
Sep	Final trimester
Oct	Peak birthing
Nov	Peak birthing
Dec	Creche period
Lactation	

3.4 Flying-fox conflict issues

The GHFF is in decline across its range. Key direct and indirect threats include:

- loss of foraging habitat
- conflict with humans (including culling at orchards)
- infrastructure-related mortality (e.g. entanglement in barbed wire fencing and fruit netting, power line electrocution etc.)
- predation by native and introduced animals
- exposure to extreme natural events such as cyclones, drought or bushfire
- construction and event noise
- splintering of the camp
- impacts to pregnant females
- impacts to crèching young.

Flying-foxes have limited capacity to respond to these threats and recover from large population losses due to their slow sexual maturation, small litter size, long gestation and extended maternal dependence (McIlwee & Martin 2002).

3.4.1 Disease

Flying-foxes, like all animals, carry pathogens that may pose human health risks. In Australia, the most well-defined are Australian Bat Lyssa Virus (ABLV) and Hendra Virus (HeV). Further information is provided in Appendix 1.

Appropriate protocols (as per Section 6.6) and Personal Protective Equipment are required for people working in and around flying-fox camps and will be dependent on the type of activity.

Management actions or natural environmental changes may increase disease risk by:

- forcing flying-foxes into closer proximity to one another, increasing the probability of disease transfer between individuals and within the population.
- resulting in abortions and/or dropped young if inappropriate methods are used during critical periods of the breeding cycle. This will increase the likelihood of direct interaction between flying-foxes and the public, and potential for disease exposure.
- adoption of inhumane methods with potential to cause injury which would increase the likelihood of the community coming into contact with injured/dying flying-foxes.

The potential to increase disease risk (Appendix 1) should be carefully considered as part of a risk assessment prior to commencing any on-ground works. Refer to section 6.6 for personal protective measures.

3.4.2 Heat stress events

Flying-foxes suffer from heat stress when the ambient temperature exceeds the physiological limits flying-foxes can endure for maintaining a comfortable body temperature (Bishop 2018). Flying-foxes are susceptible to heat stress due to their inability to sweat (Snoyman et al 2012), therefore they need to expend energy on cooling mechanisms such as fanning. Temperatures above 38ºC, consecutive hot days, lactation and camp demographics and other weather variables such as high humidity contribute to the likelihood of a Heat Stress Event (HSE) (Bishop 2014, Collins 2014, Welbergen et al 2008).

A flying-fox is considered to be suffering from heat stroke once fanning and shade-seeking is no longer effective and must resort to panting and salivating to reduce body temperature. The point at which heat stroke develops varies with each individual's behaviour and metabolic rate (Bishop 2014). Heat stroke is the cell damage that occurs from enduring the effects of prolonged exposure to heat and the physical effort (exertion) involved to dissipate heat.

Exertional heat stroke can lead to myopathy (muscle damage), rhabdomyolysis (breakdown of muscle causing kidney damage) or multi-systemic damage to gastrointestinal tract, renal, circulatory, nervous or respiratory systems as well as death.

Whilst there is no obligation for NCA to mitigate against heat stress impacts at a flying-fox camp, proactively managing these events will:

- minimise potential welfare impacts
- support conservation of the threatened GHFF
- minimise flying-fox mortality which will also reduce the potential for impacts to community amenity and/or health
- reduce the likelihood of close interactions with people and flying-foxes which may result in a bite or scratch
- minimise costs and energy expended by reactively managing a heat stress event (HSE) (i.e. carcass collection and disposal).

It is important to recognise that intervening at an inappropriate time or under certain circumstances can be more detrimental than beneficial. Welbergen (2012) suggests intervention is generally not recommended, unless animals are still unresponsive after temperatures have dropped below ~37°C. As such, a response plan should only be considered when guided by people with extensive experience in managing a HSE. Appendix 2 provides an Extreme Weather Event Response Plan for dealing with such events including HSEs.

3.4.3 Flying-foxes and aircraft

Collisions between wildlife and aircraft (wildlife strikes) are common aviation safety occurrences and cost Australian civil aviation an estimated AU$50M per year (McKee and Shaw 2016). Strikes to aircraft involving large birds or bats and those involving more than one animal (multiple strikes) can be serious, potentially disabling aircraft and resulting in major

accidents.

Flying-foxes are large animals that transit in large numbers at relatively low altitudes. Consequently, in terminal airspace, where aircraft are also operating at low altitudes, they may present a significant risk to air safety. Currently in Australia, flying-foxes are the most common species struck by aircraft and, depending on aircraft type, 13-20% of these collisions cause damage to the aircraft (ATSB 2017).

For any strike reduction program to be effective it is imperative that wildlife congregations in the vicinity of the aerodrome are identified, monitored and managed. Under international (ICAO Annex 14) and national legislation (NASAF-C) airport operators are required to identify potential wildlife hazards in the vicinity and convene a local stakeholder group to help reduce the risk of strike associated with those hazards. National guidelines (NASAF-C), identify a 13 km radius from airports within which strike risk should be jointly managed by land holders and airport managers. Commonwealth Park is approximately 5 km from Canberra Airport.

Airport operators should negotiate with land use planning authorities and land managers on action plans for monitoring and, where necessary, reducing wildlife attraction to areas in the vicinity of airports.

4 Camp characteristics

4.1 Camp description

Commonwealth Park is a large (34.25 ha) landscaped park on the edge of Lake Burley Griffin on the corner of Parkes Way and Commonwealth Avenue. The park is managed by the NCA on behalf of the Commonwealth Government. It is located on National Land, as defined under the PALM Act.

Roost trees primarily consist of pine trees, eucalypts, poplars and oaks with an intermittent understory in the Rhododendron Garden, Regatta Point (Figure 2). Canopy trees appear in good condition with limited defoliation. The condition and quality of trees are maintained by park contractors including the removal of dead or dying trees for staff and visitor safety.

Figure 2 Commonwealth Park pine trees with roosting flying-foxes

4.2 Camp history

The Australasian Bat Society (ABS) has been surveying the camp since it was first recorded in 2003. The camp has been occupied seasonally every year and the maximum number of GHFF recorded at the camp was 8,190 in March 2019 (Figure 3). The maximum camp extent is 1.47 ha (Figure 4). There have been anecdotal reports of flying-foxes roosting at Anzac Parade in heritage trees in January 2018. Peak numbers recorded at the Park in January 2018 were 4477, almost half the maximum. Therefore, it is likely this splinter group was not the result of an influx, more likely a temporary disturbance at the Park. However, it highlights the potential for flying-foxes to establish at this highly undesirable location, and the importance of maintaining suitable habitat at the Park.

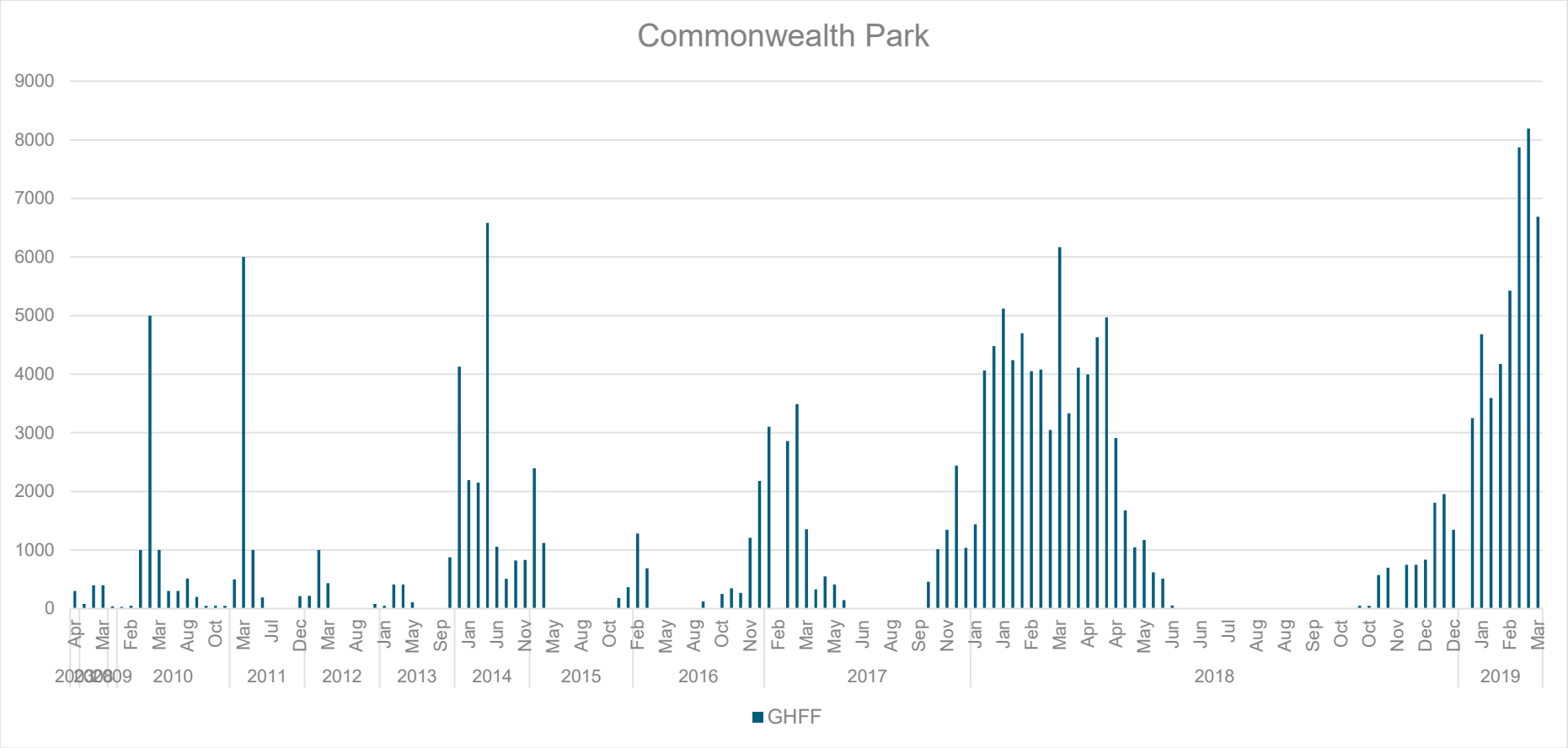

Figure 3 Historic occupation of Commonwealth Park Source: ABS 2019

Figure 4: Maximum camp extent

National Capital Authority

Commonwealth Park Flying-fox Management Plan

ecosure

Job number: PR4115
Revision: 0
Author: KF
Date: 30/04/2019

0 25 50 100
Metres

GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994
Units: Meter

4.3 Potential habitat analysis

While it is recognised that flying-fox camp selection is difficult to predict, known favoured characteristics were modelled up to 20km from Commonwealth Park (Figure 5) to identify where the camp might relocate due to intended or inadvertent disturbance. Detailed methods for this modelling are provided in Appendix 3.

It must be noted that while this assessment was based on known camp preferences, there were some limitations to the available data. The modelling does not mean that flying-foxes will select highlighted areas, or that camps will not form in less preferable habitat.

When mapped vegetation immediately around the camp was ground-truthed by assessors, potential sites flying-foxes could relocate to were identified and are illustrated in Figure 6. These sites were considered to contain preferred camp features (section 3.2). Images of each of these locations are provided in Figures 7-9, along with Anzac Parade (Figure 10), where anecdotal sightings of flying-foxes camping have been reported.

4.4 Camp relocation/dispersal

If flying-foxes were to relocate voluntarily or inadvertently due to inappropriate camp management, sensitive receptors in Canberra may be impacted (Figure 5). Sensitive receptors are schools and child care centres, aged care, hospitals, equine centres and airports; locations that present a higher risk to vulnerable people or flying-foxes themselves. Some of the schools lie in between the existing site and potential likely camp locations. The sensitive sites are illustrated in the mapping as medium risk habitat potential. Residential areas although often undesirable, are not a considered a ‘sensitive receptor’ in this context given that impacts are amenity-based (rather than risk-based). If flying-foxes relocate to sensitive sites, early dispersal actions may be considered to avoid future conflicts.

Relocating flying-fox colonies via active dispersal involves disturbing flying-foxes at the camp as they attempt to return from nightly foraging. Flying-foxes commonly abandon a camp after one or two weeks of daily dispersal, moving to nearby camps or often creating one or several new camps very nearby. Despite this, flying-foxes have a very high level of fidelity to established camp sites, and attempts to re-establish the camp will continue, often for many years.

As such, dispersal is rarely successful in the long-term without significant vegetation removal to make the site undesirable for roosting flying-foxes. Flying-foxes will almost always select another site in the local area (generally within 600 m; Roberts and Eby 2013) and often splinter into several locations nearby (including potentially remaining at the original site). Roberts and Eby (2013) summarised 17 known flying-fox dispersals between 1990 and 2013 (Appendix 4).

Dispersal should only be considered when actual risk or significant impacts cannot be managed using other methods. Dispersal is not currently being considered for the Park, but only if flying-foxes were to attempt to establish a new camp in an undesirable or sensitive location. A dispersal plan would be required prior to any dispersal action to ensure associated risks are suitably managed.

Figure 5: Proximity of sensitive sites to existing and potential flying-fox camps

National Capital Authority

Preparation of a Management Plan for Grey-headed Flying Fox Colony in Commonwealth Park

Existing/previous flying-fox camp locations

Potential future flying-fox camp locations

Canberra International Airport

School or child care facility

Habitat Potential

4 - 15 Low

16 - 20 Medium

21 - 25 High

ecosure

Job number: PR4115
Revision: 2
Author: RSC
Date: 20/03/2019

0 150 300 600
Metres

GDA94 MGA zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Units: Meter

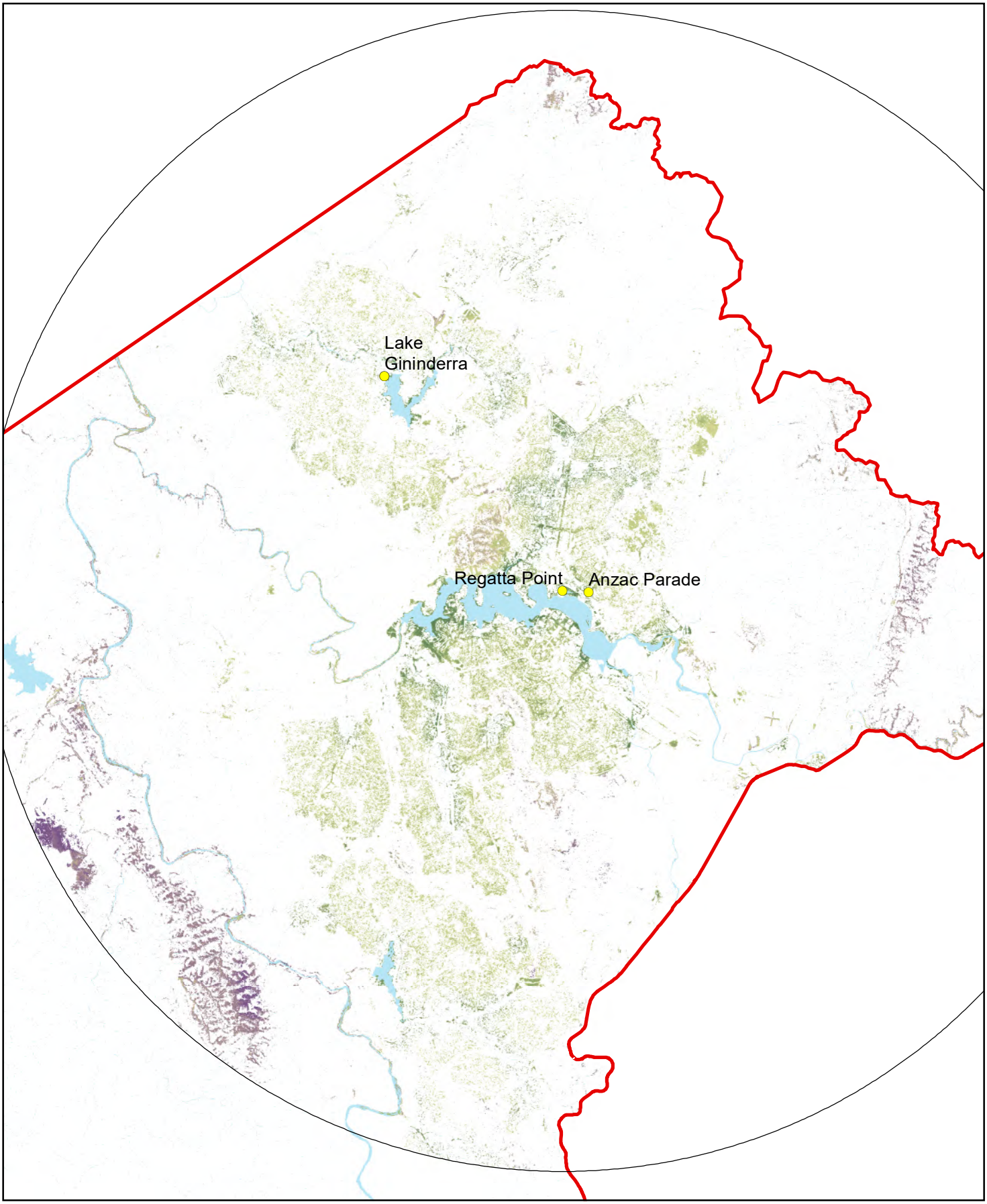

Figure 6: Flying-fox habitat potential

National Capital Authority
Preparation of a Management Plan for Grey-headed Flying Fox Colony in Commonwealth Park

Existing/previous flying-fox camp locations
20km radius around Commonwealth Park camp
Australian Capital Territory boundary
Water body

Potential Habitat Scores
High : 25
Low : 4

ecosure

Job number: PR4115
Revision: 2
Author: RSC
Date: 20/03/2019

0 1 2 4
Kilometers

GDA94 MGA zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Units: Meter

Report Figure 7 Commonwealth Park Habitat Potential - zoomed out
A4

Figure 7 Sullivans Creek contains complex vegetation structure preferred by flying-foxes

Figure 8 Botanical Gardens gully contains the complex vegetative structure and understory preferred by flying-foxes

Figure 9 Glebe Park has similar characteristics as Commonwealth Park and could attract flying-foxes

Figure 10 Anzac Parade where flying-foxes have been previously sighted

Figure 11: Potential flying-fox habitat classes with locations of possible future camps

National Capital Authority

Preparation of a Management Plan for Grey-headed Flying Fox Colony in Commonwealth Park

Potential future flying-fox camp locations

Habitat Potential

- 4 - 15 Low
- 16 - 20 Medium
- 21 - 25 High

ecosure

Job number: PR4115
Revision: 2
Author: RSC
Date: 20/03/2019

0 50 100 200
Metres

GDA94 MGA zone 55
Projection: Transverse Mercator
Datum: GDA 1994
Units: Meter

5 Management approach

The GHFF camp in Commonwealth Park does not currently meet the criteria for a nationally important camp (Section 2.1.1), however it is likely to in the future and could become one at any time. In the last decade, the camp has contained over 2,500 flying-foxes in seven out of 10 years. The maximum number of flying-foxes recently peaked at 8,190; with the potential for the camp to support 10,000 flying-foxes, it may become nationally important. Therefore, the Park will be managed using best practice approach to ensure the highest level of protection is afforded to the GHFF and their camp. NCA is committed to protecting the GHFF as a MNES and will to continue to promote their value to Park personnel and patrons.

No data exists on the cumulative impacts of organised events around flying-fox camps, nor have those effects been measured at Commonwealth Park. The camp's resilience to and ability to respond to these types of activities is unknown and current understanding of camp health relies on sporadic observations. The Plan provides guidelines for the three Management Sectors - Park Management, Tree Management and Event Management to report on the efficacy of recommended guidelines and adapt mitigation where necessary. Data gathered through this Plan will serve as a baseline for future management decisions.

NCA takes a risk-based approach to proposed mitigation strategies based on:

- potential health, safety, wellbeing and economic implications for the staff and public
- potential flying-fox welfare and conservation impacts
- risk of splintering the camp to other locations that are equally or more problematic.

Current and proposed users of Commonwealth Park should assess whether their activity requires management or mitigation to reduce direct or indirect impacts to the camp.

Process for assessing a proposed activity and its risk to the flying-fox camp:

1. Determine the type of activity
2. Determine the risk to flying-foxes or camp habitat
3. Identify suitable mitigation options
4. Describe how these options will be applied
5. Report on the outcomes of the mitigation.

It is the responsibility of all personnel to ensure compliance with the Plan.

5.1 Type of activity/disturbance

The following actions in or near GHFF camps are defined as being unlikely to have a significant impact and therefore are unlikely to require approval under the EPBC Act:

- minor, routine camp management at any camp
- clearing vegetation, dispersal of animals, in situ flying-fox management or other impacts on flying-fox camps, that are *not* nationally important flying-fox camps, that is carried out in accordance with state or territory regulatory requirements.

Activities that are identified as routine camp management may have the potential to reach medium to high impact on the camp depending on:

- duration
- frequency and intensity (i.e. noise level produced)
- timing within GHFF breeding cycle (i.e. high-risk period).

Table 3 lists the type of activities considered routine camp management or medium to high impact camp management for Commonwealth Park.

Table 3 Types of disturbance to flying-foxes or their camp

Routine camp management	Medium to high impact camp management
· mowing grass and similar grounds-keeping activities · application of mulch or removal of leaf litter, rubbish or other material on the ground · weed removal, minor trimming of understorey vegetation or the planting of vegetation · removal of tree limbs or a small proportion of the whole trees in a camp if they are significantly damaged and pose a health and safety risk, as determined by a qualified and experienced arborist · planting vegetation and minor habitat restoration · minor habitat augmentation for the benefit of the roosting animals · installation of signage or similar-scale infrastructure · passive recreation (i.e. low noise recreation) · educational activities, such as study or observation of roosting flying-foxes.	· habitat modification · clearing vegetation · acoustic disturbance · sound checks / concerts · visual disturbance · physical disturbance · disturbance with smoke · operations which result in excessive noise e.g. chainsaws, chippers · fireworks · gunfire or explosions · low flying aircraft (including jets, helicopters and hot-air balloons).

5.2 Determining risk to flying-foxes

Spring to summer is the highest risk period in the GHFF breeding cycle, (i.e. during pregnancy, when dependent young are present or crèching and flightless, or when they are left in the camp overnight). Summer is also when flying-foxes will be susceptible to heat stress events. Medium risk periods are generally later in the summer to account for late breeding. Low risk is considered outside the breeding season (Figure 13).

Table 4 Critical breeding period and potential level of risk for flying-foxes from works or activities

Month	FF breeding	Potential risk to FF
Jan	Creche period	M
Feb	Creche period	M
Mar	Peak conception	M
Apr	Peak conception	L
May		L
Jun		L
Jul		L
Aug		L
Sep	Final trimester	M
Oct	Peak birthing	H
Nov	Peak birthing	H
Dec	Creche period	H

Lactation

Mitigation and management measures applied should increase with each level of risk (Table 5).

Table 5 Risks and actions for mitigation

	Risk level	Management required
	Low risk Dependent young unlikely to be present/impacted	Flying-fox monitoring not required unless advised by flying-fox expert. Generally low risk but damage to trees must be avoided and losses replaced
	Moderate risk Dependent young may be present.	Monitoring for new activities or activities with unknown level of risk. Proposed activity required to modify activity where possible to reduce impacts to flying-foxes. Authorisation or advice by flying-fox expert required prior to proposed activity.
	High risk Dependent young may be impacted.	Proposed activity to be avoided or modified during this period Implement mitigation measures to reduce impacts to flying-foxes. Authorisation or advice by flying-fox expert required prior to proposed activity Flying-fox monitoring required before, during and after proposed activity.

6 General mitigation

6.1 Modification of activity

Modification of proposed activities to reduce impacts can be achieved using the hierarchy of controls:

- Avoid (i.e. avoid undertaking activity under camp boundary, avoid critical breeding season, avoid excessive noise or machinery within 100 m of the camp)
- Reduce/control (i.e. reduce the frequency, intensity duration of activity)
- Monitor/adapt (i.e. monitor high impact activities and report to NCA).

6.2 Appropriate timing

Non-critical maintenance activities will ideally be scheduled when the camp is naturally empty (winter to early spring). Where this is not possible (e.g. at permanently occupied camps) they will be scheduled for the best period for that camp (e.g. during the nonbreeding season, generally May to Aug).

Any daytime works likely to disturb flying-foxes so that they suddenly take flight will be avoided during the birthing period (i.e. when females are carrying pups, generally September to December). Night works will be avoided when crèching young are flightless (generally November/December to January).

If this is not possible, a person experienced in flying-fox behaviour will monitor the camp for at least the first two scheduled actions (or as otherwise deemed to be required by that person) to ensure impacts are not excessive and advise on the most appropriate methods (e.g. required buffer distances, approach, etc.).

6.3 Monitoring / reporting

By monitoring activities, actual impacts to the camp can be identified or disregarded. Monitoring will help decision makers measure camp resilience and tolerance to Park operations and events. Once measured and deemed low risk, monitoring, reporting or mitigation of some activities may no longer be required.

Each monitoring event will record the number of flying-foxes present, approximate sex ratio, health condition, breeding activity and approximate age of young (if present). The following flying-fox behaviours will be noted:

- resting
- grooming
- vocalising and interacting
- mating or breeding activity

- lifting in response to sudden noise
- signs of stress (see Section 6.1.4)
- morbidity/mortality.

Frequency of monitoring for medium to high risk activities in the first year of the Plan:

- once immediately prior to proposed activity
- during activity (duration of monitoring required to be determined by flying-fox expert)
- immediately following completion.

A monitoring template is provided in Appendix 5.

Results of year 1 monitoring will inform monitoring requirements for subsequent years e.g. monitoring may be reduced to high risk periods/events only. Results of year 1 monitoring are provided in Appendix 6.

General requirement is for monitoring by someone experienced with flying-fox behaviour and capable of rescue at least monthly (and at times most likely to cause disturbance, as advised by a flying-fox expert) during all medium to high risk events.

6.4 Flying-fox expert/camp monitors

A flying-fox expert or knowledgeable person will have the following understanding of signs of stress in flying-fox behaviour (Table 6) and may call for proposed activities to cease or be modified to ensure flying-fox welfare and compliance with legislation and the Plan. Camp monitors should be vaccinated and able to competently evaluate the effects of the event as listed in Appendix 5 Monitoring Form.

NCA should develop a Memorandum of Understanding with volunteer groups (such as ACT Wildlife) regarding activities where coordination between parties is necessary to protect the flying-fox.

Table 6 Signs of stress in flying-foxes

Potential impact	Signs
Initial signs of stress	· flying-foxes are generally agitated and likely to take flight.
Unacceptable levels of stress	· panting · saliva spreading · located on or within 2 m of the ground · unusual vocalisations · >50% of the camp take flight · flying-foxes in flight for more than 2 minutes · flying-foxes leave the camp during daylight hours.
Dependent young at risk	· adults moving away from dependent young · adults carrying young being disturbed.
Injury/death	· a flying-fox appears to have been injured/killed on site (including aborted foetuses).

6.5 Education and awareness programs

Education and awareness programs help increase community understanding and improve perceptions of flying-foxes.

General community programs may include the provision of information via webpage, social media, hard media, shows and festivals, interpretive signage and educational material. Messages should have a conservation focus - for example, encouraging the replacement of barbed wire fences with plain wire and removal of non-native foraging trees that negatively impact on flying-foxes and the environment (e.g. Cocos palms). Flying-foxes could be promoted as an ecotourism opportunity, for example, Australasian Bat night http://ausbats.org.au/australasian-bat-night/4581984807 or Batty Boat Cruises have been running regularly since 1984 for tourists to watch flying-foxes leave their camps from the Brisbane River.

It is recommended NCA implement the following education measures:

- develop and implement public education programs that help increase understanding and awareness of flying-foxes, their behaviours and ecological role
- relevant training for all staff/community involved in any flying-fox management action and those who interact with the public
- install interpretive signage on flying-foxes near the camp
- collaborate with wildlife rescue and care organisations to monitor HSEs, and complete the online data form for input into the national database (https://www.animalecologylab.org/heat-stress-data-form.html).

6.6 Personnel protective measures around camp

Under no circumstances should any staff or contractors attempt to touch or handle a live flying-fox without the appropriate training and vaccinations.

If a flying-fox needs to be rescued, a flying-fox specialist (e.g. ACT Wildlife) must be contacted immediately. If a flying-fox is on or near the ground, an exclusion area should be established and clearly demarcated to prevent human interaction with the animal. The following precautions should be adopted when working in the known camp areas:

- all personnel inducted and briefed prior to works commencing.
- all personnel to wear appropriate personal protective equipment (PPE): long sleeves and pants, eye protection, gloves, broad-brimmed hat.
- all personnel working underneath the camp during machine operations that disturb the substrate (cause dust) or could aerosol flying-fox excrement to also wear protective breathing equipment.
- adopt appropriate hygiene practices such as hand washing with soap and water before eating or smoking.

- all personnel working underneath the active camp to wash clothes daily. Work crews should also have a spare set of clothes to change into at end of shift in the event clothes are contaminated with flying-fox urine and/or faeces.
- if a person is bitten or scratched by a bat, the wound should immediately be washed (**not scrubbed**) with soap and water for at least five minutes, followed by application of an antiseptic with anti-viral action (e.g. Betadine) and seek immediate medical attention (post-exposure vaccinations may be required).
- medical attention should also be immediately sought if a person is exposed to an animals' saliva or excreta through the eyes, nose or mouth.

Carcass (dead animal) removal does not require special training or vaccinations and can be safely undertaken using the following precautions:

- use a shovel or tool to pick up the carcass.
- collect the carcass in a bio-hazard bag or heavy plastic container or bag and dispose in a commercial rubbish receptacle that does not require manual handling.

7 Park management guidelines

7.1 Likely impacts to camp

NCA's contractors are responsible for Park maintenance such as mowing of grass, garden care and path maintenance. Although machinery does create noise disturbance, flying-foxes can tolerate and habituate to consistent and low levels of noise. Excessively loud, sharp, sudden and high-pitched sounds, such as those from a wood chipper or chainsaw, will cause more stress for flying-foxes and should be considered a moderate-high risk activity (moderate risk during the non-breeding season; high risk during the breeding season when flightless young are likely to be present, see Section 5.2).

7.2 Mitigation measures to reduce impacts

The following mitigation measures (Table 7) are for park management activities causing disturbance to flying-foxes and the camp, including recommended durations of disturbance. All general mitigation measures in Section 6 also apply.

Table 7 Park management mitigation measures

Disturbance	Activity	Frequency	Maximum Duration	Mitigation required
Routine camp maintenance	Mowing	September to March Wednesday afternoon and Thursday morning Fortnightly to monthly in winter Weekly Spring to Autumn	6 hours / day 18 hours / week	The action must not occur during or immediately after climatic extremes (HSE, cyclone event), or during a period of significant food stress. Mowing should begin as far from the camp as possible to allow animals to become accustomed to the disturbance
	Driving mowers directly under camp	Not permitted	Not permitted	Install bollards on footpaths to prevent machinery driving directly under camp at Rhododendron Garden.
	Chipping	As required	2 hours/day 10 hours/week At 100 m	Vegetation chipping is to be undertaken as far away from roosting flying-foxes as possible (at least 100 m). Must not occur if the camp contains females that are in the late stages of pregnancy or have dependent young that cannot fly on their own.
	Using loud machinery	As required	2 hours/day 10 hours/week At 100 m	The use of loud machinery and equipment that produces sudden impacts/noise will be limited. Where loud equipment (e.g. Chainsaws) is required they will be started away from the camp and allowed to run for a short time to allow flying-foxes to adjust (OEH 2016).
	Mowing, chipping, using loud machinery	As required	Not permitted	No maintenance works to be undertaken within 50m of closest flying fox if the temperature is over 35°c (i.e. Potential for HSE).

7.3 Garden refurbishments

To protect the longevity of the roost trees, the area identified as the maximum camp extent (Figure 4) requires planting to replace lost canopy trees and the re-establishment of a shrub layer to preserve the microclimate and as refuge during heat events. Although the camp does not occupy the maximum camp extent all year, planting in this area should allow for influxes and the likely increase in the camp population.

Lawn under roosting trees should be replaced with suitable understory species already existing in the camp to provide a structure and density preferred by the flying-foxes in the core of the camp.

Depending on species, trees planted within the core camp area may take 6-8 years before they reach 5m and are used by flying-foxes for roosting. If trees are planted at the edge of the camp rather than in gaps within the camp, this can increase to 10 years (SEQ Catchments 2012). Fast growing species favoured by flying-foxes should be preferentially selected (e.g. *Casuarina spp.*)

Understanding which tree species may be more resilient to damage from roosting animals than others can help guide revegetation activities. Resilient roost trees need the following qualities in addition to ecosystem specific attributes:

- resilient to defoliation e.g. red ash (*Alphitonia excelsa*) which is frequently denuded by insects
- tolerant of high nutrient levels (high phosphorus benefits weeds, but impacts many native species)
- resistant to soil pathogens
- thick bark (resistant to damage from claws)
- avoid species with terminal growth points that are broken off by flying-foxes (SEQ Catchments 2012).

8 Tree management guidelines

Protecting the camp vegetation structure and quality is important because of the limited roosting space available for the flying-foxes in the camp and the lack of other suitable camp locations in the area. Effective tree and camp management will:

- help flying-foxes to cope with HSE
- prevent flying-foxes from abandoning the camp and relocating to undesirable locations.

8.1 Likely impacts to camp

8.1.1 Damage to vegetation by flying-foxes

Large numbers of roosting flying-foxes can damage vegetation however, this should be considered in the context of the critical ecological services flying-foxes provide and the associated benefits to other species. Most native vegetation is resilient and generally recovers well (e.g. casuarina and eucalypts) and flying-foxes naturally move within a camp site allowing vegetation to recover. However, damage can potentially be significant and permanent, particularly in small patches of vegetation. Intervention may be required if permanent damage is likely.

8.1.2 Damage to vegetation from operations and events

Over 60 dead or damaged trees have been removed in Commonwealth Park in the last five years due to event-related activities. Uneven watering and significant disruption to tree roots from construction and heavy equipment and vehicle movement (McIlroy 2016) are likely causes. Dead trees require removal for the safety of park users and staff working underneath vegetation.

8.2 Mitigation measures to reduce impacts

The following mitigation measures (Table 8) are provided for activities causing disturbance to flying-foxes and the camp. All general mitigation measures in Section 6 also apply.

Table 8 Tree management mitigation measures

Disturbance	Action	Frequency	Maximum Duration	Mitigation
Tree fall	Chain-sawing, chipping	Not limited if camp is empty	Not limited if camp is empty	Winter (when the camp is empty) is the ideal time to undertake actions that disturb flying-foxes
Tree fall (including removing dangerous trees) or death	Chipping	As required	2 hours/day 10 hours/week At 100 m	Vegetation chipping is to be undertaken as far away from roosting flying-foxes as possible (at least 100 metres). Must not occur if the camp contains females that are in the late stages of pregnancy or have dependent young that cannot fly on their own.

Disturbance	Action	Frequency	Maximum Duration	Mitigation
	Chain-sawing	As required	2 hours/day 10 hours/week At 100 m	Any tree lopping, trimming or removal is undertaken under the supervision of a suitably qualified arborist who is a member of an appropriate professional body such as the National Arborists Association.
			2 hours/day 10 hours/week At 100 m	No tree in which a flying-fox is roosting will be trimmed or removed.
			2 hours/day 10 hours/week At 100 m	A person experienced in flying-fox behaviour is to remain on site to monitor, when canopy trimming/removal is required within 50 metres of roosting flying-foxes.
	Habitat restoration	Annually	No limit if hand tools used	Succession planting. Offset trees lost on site with fast growing species to replace canopy lost Species selected for revegetation will be consistent with the habitat on site.
			No limit if hand tools used	Weed control in the core habitat area will be undertaken using hand tools only (or in the evening after fly-out while crèching young are not present).
Heat stress	Habitat restoration	Annually	No limit if hand tools used	Habitat restoration and landscaping in understory using species consistent with habitat on site should be extended to the edge of the camp canopy dripline
	Chipping, using loud machinery	As reguired	not permitted	No tree works to be undertaken within 50m of closest flying fox, if the temperature is over 35°C (i.e. potential for HSE).
Root damage	Displays	Annually	9 months	Reconfigure events which have footprint within the Colony Area. No structures built under dripline of canopy Displays within 50m of camp must be rostered off or relocated from those areas every other year
	Bump in / bump out	Annually		No construction under dripline of canopy
	Temporary path construction	Annually		No construction under dripline of canopy

9 Event management guidelines

NCA Events team is responsible for managing organisers of events on NCA estate. To ensure the well-being of the GHFF camp in the Park, opportunities should always be taken to modify events where possible or enforce mitigation management practices when required.

9.1 Likely impacts to camp

Flying-fox numbers have steadily increased in the Park, indicating the camp can tolerate and habituate to disturbance. Impacts to flying-foxes from events include disturbance to rest periods, particularly during the day due to noise. Sharp, sudden and high-pitched sounds such as those from fireworks or cannons will cause more stress for flying-foxes and should be considered a high-risk activity. Events occurring during high and medium risk periods of the GHFF breeding season are shown in Figure 14. Concerts and events include bump in and bump out periods for set up and pack down, extending the duration of impact for a one-day event. For example, Floriade runs for one month but spends another eight months of the year in construction. Aircraft including hot air balloons, planes, helicopters, military aircraft or drones can cause significant impact on the colony, creating particular stress on the animals and as they take flight on mass, pose an increased risk to the aircraft.

Late and out of breeding season is common, therefore this is taken into consideration with March allocated as medium risk, whilst young in the creche still gain flight stamina and strength.

Table 9 Event occurring during medium and high risk periods of the GHFF breeding season

Month	FF breeding	Potential risk to FF	Events
Jan	Creche period	M	Australia Day
Feb	Creche period	M	Floriade
Mar	Peak conception	M	Skyfire, Canberra Day Symphony in the Park Floriade
Apr	Peak conception	L	Floriade, Anzac Day
May		L	Floriade
Jun		L	Floriade
Jul		L	Floriade
Aug		L	Floriade
Sep	Final trimester	M	Floriade
Oct	Peak birthing	H	Floriade
Nov	Peak birthing	H	Spilt Milk
Dec	Creche period	H	

Lactation

Figure 12: Commonwealth Park camp location

National Capital Authority

Commonwealth Park Flying-fox Management Plan

Aerial exclusion zone

ecosure

Job number: PR4115
Revision: 0
Author: KF
Date: 19/03/2019

0 25 50 100
Metres

GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994
Units: Meter

PR4115_MP5_Context
A4

9.2 Mitigation measures to reduce impact

The following mitigation measures are provided for events deemed medium to high risk to flying-foxes and the camp. Although the impacts from Floriade are indirect, the cumulative impacts from changed water regimes and compaction of soil and roots is known to contribute to the death of trees on an annual basis. This is a major concern for the available habitat and the limited extent of roosting space for the colony. Table 7 outlines required mitigation measures. All general mitigation measures in Section 6 also apply.

Table 10 High risk events in Commonwealth Park

Disturbance	Risk period	Action	Frequency	Duration	Mitigation
Australia Day	Medium	Fireworks	1 night	20 minutes	Camp monitoring and vaccinated person on site to rescue if required.
	Medium	Gun salute	1 day	20 minutes	200 m exclusion zone from Rhododendron Gardens Camp monitoring and vaccinated person on site to rescue if required.
Skyfire	Medium	Fireworks	1 night	20 minutes	Camp monitoring and vaccinated person on site
Floriade	High (October) Medium	All activities	Annual	9 months	Reconfigure displays so that roost trees are not impacted. Delineate exclusion zone under roost trees Replace (like for like) any damaged roost tree or understorey vegetation. Camp monitoring to ensure displays not set up under camp boundary
Large multi-stage music events (e.g. Spilt Milk)	High	Concert during the day and night, multiple stage	Annual	12 hours	Camp monitoring and vaccinated person on site to rescue if required. A person experienced in flying-fox behaviour will monitor the camp for at least the first two scheduled actions
Any aircraft flying low over Park	Medium	All	Various	Various	200 m exclusion zone from Rhododendron Gardens

9.3 Specific events conditions

- All events are to be excluded from the Camp Area (Figure 6).
- Food venders, temporary structures and their associated back of house areas must not be set up within the Colony Area, including the drip zone of the associated trees.
- All excavation is to be excluded within the Colony Area, including the drip zone of the associated trees.
- Aircraft including hot air balloons, planes, helicopters, military aircraft or drones will need to maintain a 200m exclusion zone (Figure 15) from Rhododendron Garden at Commonwealth Park for the welfare of GHFF.

- When requested by the NCA, Event organisers must undertake monitoring of the camp during high risk events. Monitoring must be undertaken by experienced specialists with appropriate vaccinations (see Section 6.4 Flying –fox expert/camp monitors). Camp monitors should be able to competently evaluate the effects of the event as listed in Appendix 5 Monitoring Form.

10 Plan administration

10.1 Monitoring

Data gathered through mitigation and guidelines recommended in this Plan will serve as a baseline for future management decisions. NCA will keep internal records to monitor the effectiveness of each management action to inform future planning. The Plan is an adaptive document that can be updated as situations change, further monitoring data are available, and/or research improves our understanding of flying-foxes and management of community impacts. Data showing the camp's resilience and tolerance will help NCA determine ongoing monitoring requirements.

10.2 Plan review

This plan should be seen as a working adaptive document. The following reviews should be undertaken:

- data collected from event monitoring – annually
- high risk event monitoring reviewed and ceased where suitable
- entire plan updated every 5 years.

10.3 Key recommendations

The following key recommendations stand for Commonwealth Park:

- Activities must not occur within the Colony Area during or immediately after (heat stress events or during a period of significant food stress.
- Any activity likely to disturb flying-foxes so that they take flight will be avoided during the day during the sensitive GHFF birthing period (Oct/Nov), and at night when flightless young are crèched (Dec-Feb).
- Activities that cannot avoid high risk periods will require that a person experienced in flying-fox behaviour will monitor the camp for at least the first two scheduled actions (or as otherwise deemed to be required by that person) to ensure impacts are not excessive.
- Habitat restoration and landscaping in camp understory should be extended to the edge of the camp canopy dripline to prevent unnecessary works or activity under camp (See Section 7.3 Garden Refurbishments).
- Any event (including Floriade) must not excavate or erect structures within the Camp Area, including the drip zone of the associated trees, to prevent damage to tree roots and the potential loss of habitat and roosting trees.
- Aircraft including hot air balloons, planes and military aircraft either will need to obey exclusion zones of 200m (Figure 6) from Rhododendron Garden for GHFF welfare.

- Educational signage to be installed near camp and encourage ecotourism and public/education programs to promote the ecological value of flying-foxes. (See Section 6.5 Education and Awareness Programs).

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Appendix 1 Flying-foxes and human health

In Australia, diseases of concern are Australian bat lyssavirus (ABLV) and Hendra virus (HeV).

Except for those people whose occupations include close contact with bats or potentially infected domestic animals (such as wildlife carers and veterinarians) human exposure is extremely rare. These diseases are also easily prevented through vaccination, safe flying-fox handling (by trained and vaccinated personnel only) and appropriate horse husbandry. Therefore, despite the fact that human infection with these agents can be fatal, the probability of infection is extremely low, and the overall public health risk is also judged to be low (Qld Health 2016). Transmission of closely related viruses suggests that contact or exposure to bat faeces, urine or blood does not pose a risk of exposure to these viruses, nor does living, playing or walking near bat roosting areas (NSW Health 2013).

Australian Bat Lyssavirus

Less than 1% of the flying-fox population is infected with ABLV, and transmission is through a bite or scratch from an infected bat. Effective pre- and post-exposure vaccinations are available. If a person is bitten or scratched by a bat they should:

- wash the wound with soap and water for at least five minutes (do not scrub)
- contact their doctor immediately to arrange for post-exposure vaccinations.

If bat saliva contacts the eyes, nose, mouth or an open wound, flush thoroughly with water and seek immediate medical advice. No dogs or cats are known to have contracted ABLV (RSPCA 2016), however transmission is possible (McCall et al. 2005). Transmission is directly through a bite or scratch from an infected bat, so as a precaution people should prevent their dogs and cats from contacting bats. This may include keeping pets inside at night, particularly when flying-foxes are foraging on flowering or fruiting trees nearby and keeping dogs on a lead when walking near a flying-fox camp (RSPCA 2016).

Hendra virus

Flying-foxes are the natural host for HeV, which can be transmitted from flying-foxes to horses. There is no evidence that the virus can be passed directly from flying-foxes to humans or to dogs (AVA 2015). Infected horses sometimes amplify the virus and can then transmit it to other horses, humans and on two occasions, dogs (DPI 2014). Clinical studies have shown cats, pigs, ferrets and guinea pigs can also carry the infection (DPI 2015a).

Although the virus is periodically present in flying-fox populations across Australia, the likelihood of horses becoming infected is low and consequently human infection is extremely rare. Horses are thought to contract the disease after ingesting forage or water contaminated primarily with flying-fox urine (CDC 2014).

Appendix 2 Extreme weather event response plan

ecosure
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EXTREME WEATHER EVENT RESPONSE PLAN

June 2020

NATIONAL CAPITAL AUTHORITY

Acknowledgements

Ecosure would like to thank ACT Wildlife for the *ACT Wildlife Heat Stress Event Plan 2019* that supports this response plan for the National Capital Authority.

National Capital Authority and Ecosure would also like to acknowledge the great response by ACT Wildlife, ACT government veterinarians and other responders to extreme weather events at Commonwealth Park.

Acronyms and abbreviations

ABLV	Australian Bat Lyssavirus
ACT	Australian Capital Territory
BFF	Black flying-fox (*Pteropus alecto*)
BOM	Bureau of Meteorology
CP	Commonwealth Park
EWE	Extreme weather event
GHFF	Grey-headed flying-fox (*P. poliocephalus*)
HSE	Heat stress event
LRFF	Little red flying-fox (*P. scapulatus*)
MOU	Memorandum of Understanding
NCA	National Capital Authority
NSW	New South Wales
SEQ	South East Queensland
SFF	Spectacled flying-fox (*P. conspicillatus*)

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1 Introduction

The National Capital Authority (NCA) is responsible for managing the grey-headed flying-fox (*Pteropus poliocephalus*: GHFF) camp in Commonwealth Park (CP), Canberra. During the 2019-2020 summer, CP flying-foxes faced months of bushfires and lingering smoke, high temperatures, and a devastating hailstorm (ACT Wildlife 2020; McGowan & Henriques-Gomes 2020; Readfearn 2020). This document will enable NCA to facilitate and support a response to extreme weather events (i.e. heat, storms or cold snaps: EWEs) in CP smoothly and effectively.

This response plan for EWEs at CP camp will:

- support conservation of the GHFF which is listed as threatened under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and the ACT *Nature Conservation Act 2014*
- minimise potential welfare impacts associated with flying-fox injury and mortality
- reduce the likelihood of close interactions with people and flying-foxes which may result in a bite or scratch
- minimise costs and energy expended by reactively managing extreme weather events (e.g. carcass collection and disposal).

The ACT Wildlife HSE Plan (2019) provides additional on-ground processes, triage and rehabilitation and should accompany this EWE plan.

1.1 Heat stress events

Heat stress events (HSEs) can cause mass flying-fox mortality during summer. Thirty-five HSEs have occurred in Australia since 1994 (Lab of Animal Ecology 2020) including the largest on record, 45,500 deaths across 52 South East Queensland (SEQ) camps in the summer of 2014 (Welbergen et al. 2014). The second largest mass die-off occurred in Cairns in November 2018 where 23,000 spectacled flying-foxes (*P. conspicillatus*: SFF), or one third of the Australian population, died when temperatures reached over 42ºC for two days (Kim & Stephen 2018).

Factors that contribute to HSEs vary from camp to camp, depending on geographic location, weather, camp characteristics and demographics (Table 1).

Table 1 Heat stress event variables (adapted from Stanvic et al. 2013; Bishop et al. 2019)

Weather	Camp characteristics	Demographics
< 40 ºC	Size of camp and carrying capacity	No. of lactating mothers
No. of consecutive hot days	Closed canopy and understorey	No. and age of juveniles
Humidity (especially over 70% humidity)	Proximity to water	Birthing season – early or late
Wind direction	Topography/aspect/altitude	Species composition

1.1.1 Weather

Between November and February in Australia when temperatures reach over 40ºC, flying-foxes suffer varying degrees of heat stress (Welbergen et al. 2008; Stanvic et al. 2013; Bishop et al. 2019). Consecutive hot days can also increase the risk of HSEs with animals spending more time fanning than resting (see Section 1.1.3). Wind can help transport heat away from the colony and increase the effectiveness of perspiration.

Relative humidity measuring moisture in the air is expressed as the percentage of water vapour in the air relative to the amount that the air theoretically could contain at the same temperature; it is thus closely dependent on temperature (CSE 2020). Canberra's monthly mean relative humidity peaks during the colder months (85% in June) and drops off during summer (62% in December (BOM 2020)). However, one week in December 2017 recorded a relative humidity of 74% at Canberra Airport, showing that humidity is quite variable and must be monitored to ensure response is appropriate to humidity level (for example, at high temperatures the camp should not be misted which could exacerbate heat stress events).

1.1.2 Camp characteristics

Both temperature and humidity play a role in determining camp selection for flying-foxes (Snoyman and Brown 2010). The resilience of camps to heat stress conditions differs with the structure of vegetation, particularly the presence of an understorey. Flying-foxes escape the heat by seeking refuge in the mid and understorey, which can be 3°C cooler than ambient air temperature (Stanvic et al. 2013).

1.1.3 Demographics

Flying-foxes suffer from heat stress when the ambient temperature exceeds the physiological limits flying-foxes can endure (Bishop 2014). Flying-foxes are susceptible to heat stress due to their inability to sweat (Snoyman et al. 2012), therefore they need to expend energy on cooling mechanisms such as fanning. A flying-fox is considered to be suffering from heat stroke once fanning and shade-seeking are no longer effective and must resort to panting and salivating to reduce body temperature. The point at which heat stroke develops varies with an individual's behaviour and metabolic rate (Bishop 2014).

Black flying-foxes (*P. alecto*: BFF) are more susceptible to HSE than GHFF due to the southern expansion of their range with temperature extremes increasing in severity with latitude in eastern Australia (Welbergen et al. 2008). Little red flying-foxes (*P. scapulatus*: LRFF) are most adapted to high temperatures and are the least likely to be affected by heat stress.

The most vulnerable demographic group is nursing mothers, because of the heat they retain through clustering with their offspring and increased metabolic rates associated with lactation. GHFF generally birth in October-November, and therefore nursing coincides with summer and the most likely timing of HSEs. Nursing females and their young are also more prone to heat stress because they spend more time fanning and therefore less time resting if there are continual days of high temperatures. Females with young have been observed roosting on the

perimeter of the camp where it is less shaded, possibly due to forcible eviction by males and females without young, or to avoid competitive interactions for preferred perches (Bishop 2014).

Juveniles have a lower thermoregulatory capacity (Stanvic et al. 2013) which makes them the next most vulnerable demographic. The timing of the birthing season, whether earlier or later in the season, will determine the age of juveniles and therefore their ability to cope during a heat event (Stanvic et al. 2013).

1.2 Hailstorms

Little data exists on the impact of hailstorms on flying-foxes, however large hailstones have injured and killed flying-foxes in Canberra and SEQ (ACT Wildlife 2020; The Courier Mail 2012). On January 20, 2020, CP was struck by a severe hailstorm resulting in 344 dead (including 260 euthanased due to injury). A further 296 deaths (i.e. totalling 640), injuries and orphans were recorded up to 52 days after the hailstorm (ACT Wildlife 2020), highlighting the extent of welfare issues in the aftermath. Data does not account for flying-foxes that were removed and disposed of by Citywide staff before wildlife carers were on scene, nor the animals that left the camp and died elsewhere in the days that followed (ACT Wildlife 2020).

1.3 Cold snaps

Mass mortality at flying-fox camps can be caused by cold snaps in the weather, although less is documented about these types of deaths. A large number of LRFF died after a cold snap in Chinchilla, Queensland in 2018 (Morris 2018) and hundreds died at Mt Ommaney in 2016 (Schafer et al. 2016). These are examples of unusual flying-fox migratory behaviour, where the animals failed to move to warmer wintering sites, staying and even breeding in an area they normally would not. It is thought flying-fox pups may suffer hyperthermia, dropping from the tree while their mothers are searching for food.

1.4 Food shortages

Environmental conditions such as drought and bushfires result in prolonged losses of flying-fox foraging resources. This may lead to starvation events such as the one that occurred around SEQ in 2019 (Cox 2019). Food shortages increase incidents of flying-fox morbidity and mortality, and often associated increases in rescues and animals in care. However, this response is generally more widespread and less acute, and so is outside the scope of this emergency response plan.

2 Preparation

2.1 Health and safety

2.1.1 Australian Bat Lyssavirus

Australian bat lyssavirus (ABLV) is a virus that can be transmitted from bats to humans, and it should be assumed that any bat could carry the virus. Transmission is through a bite or scratch.

If a person is bitten or scratched by a bat they should:

- wash the wound with soap and water for at least five minutes (do not scrub)
- contact their doctor immediately to arrange post-exposure vaccinations.

Only ABLV-vaccinated and trained personnel are permitted to rescue flying-foxes, and only under the direction of the Site Coordinator (see Section 2.2). Clear demarcation must be made for what actions vaccinated and non-vaccinated respondents can complete (Section 2.2 Personnel roles).

2.1.2 Access

Managing the camp during extreme weather or heat may be compounded by the addition of events held in CP during summer, particularly those where loud and sudden noises occur, such as fireworks, guns, cannons or jets (refer to Monitoring Summary Report Ecosure 2020). These types of noises can cause flying-foxes to lift, increasing body temperature and diverting energy from vital body systems that are already compromised (ACT Wildlife 2020).

Due to the camp inhabiting an area in CP that hosts multiple events, NCA could organise a Memorandum of Understanding (MOU) for all lessees regarding entry for response personnel during EWEs. An MOU may allow respondents to promptly attend an EWE without uncertainty for event organisers, security, or wildlife carers during events.

NCA to identify with event organisers:

- number of personnel required (names), organisation and vehicular access points
- locations of water stations for wash down and sprinklers (Appendix 1)
- suitable location for headquarters/triage tent for treating sick or injured flying-foxes
- any additional hazards (e.g. electrical equipment, event fencing under roosting trees, evacuation points).

Sign in sheets (example Appendix 2) should be available at the headquarters or the induction point during a HSE.

2.2 Personnel roles

Figure 1 illustrates the chain of communication during an EWE at CP. Table 2 details roles, responsibilities, staffing levels and reporting lines for an EWE.

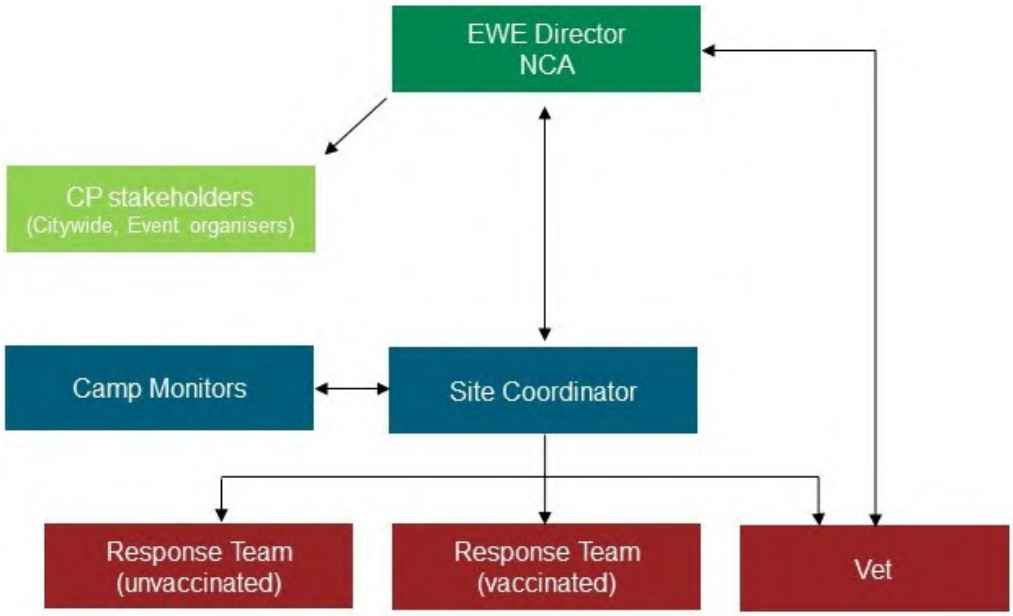

Figure 1 Chain of communication

Table 2 Personnel and responsibilities

Role	Who	Responsibilities	Reporting lines
EWE Director	NCA	Provide EWE plan to Site Coordinator Initiate HSE plan with Site Coordinator Notify Event Organisers of potential HSE Notify ACT Govt veterinarian – standby/mobilise Notify Citywide for sprinklers Supply equipment Set up debrief if necessary	Reports from: Site Coordinator ACT Govt vet
Site Coordinator	ACT Wildlife	First point of contact for Camp Monitors (see below) Initiate response plan and enforce safety protocols including personnel inductions Delegate roles and position in and around the colony according to (ABLV) vaccination status Collect data records Identify triage area or HQ Support all team members Debrief team	Reports to: EWE Director Reports from: Camp monitors Response team
Camp Monitors (Rostered)	Volunteers	Monitor temperature at weather sites (Bureau of Meteorology, [BOM] or Flying-fox HSE Forecaster tool) between November and February Monitor flying-fox behaviour Notify Site Coordinator if HSE is likely Set up sprinklers under the colony if requested by Site Coordinator Participate as required in heat stress response	Reports to: Site Coordinator

Role	Who	Responsibilities	Reporting lines
Response team (Vaccinated)	Volunteers	Monitor and observe flying-fox behaviour and report to Site Coordinator Spray water as advised by Site Coordinator /Veterinarian If trained, rescue flying-foxes where safe and appropriate to do so Collect deceased flying-foxes, checking for attached young.	Reports to: Site Coordinator
Response team (Unvaccinated)	NCA staff Citywide	Must not handle flying-foxes in any circumstances Record weather / flying-fox behaviour Register triaged animals and scribe for Vet Sign-in/sign-out participants Maintain human (e.g. water) and flying-fox supplies.	Reports to: Site Coordinator
Vet	ACT Govt Veterinarian	Flying-fox triage, rehydration, and treatment Euthanasia if necessary	Reports to: EWE Director

2.2.1 Temperature and humidity monitoring

When temperatures are predicted to reach 35ºC from November to February, camp monitors will begin monitoring temperature and humidity on weather sites or apps (note temperatures at the CP may vary from Canberra weather stations, and any consistent variation should be considered in monitoring thresholds). When temperatures reach 35ºC, camp monitors need go onsite to observe flying-fox behaviour. Camp monitors to liaise with the Site Coordinator to determine likelihood of HSE occurring. Site Coordinator will notify the EWE Director (NCA) of the need to mobilise the response. Figure 2 shows the HSE process from camp monitoring to treatment.

N.B.: Events with large crowds and heat-generating equipment have the potential to increase on-site temperatures and the risk of a HSE, and this suggested temperature threshold may need to be reduced during events.

2.2.2 Communication: before, during and after event

Members of the public should be directed not to interfere with flying-foxes during EWEs and who to call if they find any injured, malnourished, orphaned or dying flying-foxes. Media releases via NCA website or social media can help alert the public to weather conditions that lead to HSE. ACT Wildlife uses the ACT Flying-fox Disaster Management Forum closed Facebook group to upload videos or photos of behaviours to assist in determining time to enact response plan.

Good communication must be maintained between onsite personnel during the event, as hot weather also risks human impacts. Check in with personnel regarding water intake and ensure time is taken for rest periods.

Dealing with stressed or dying animals will be distressing for staff or volunteers responding to EWEs. NCA may arrange a debrief meeting to discuss processes, resources, or personal reflections and find efficiencies or improvements in the plan for both animals and people.

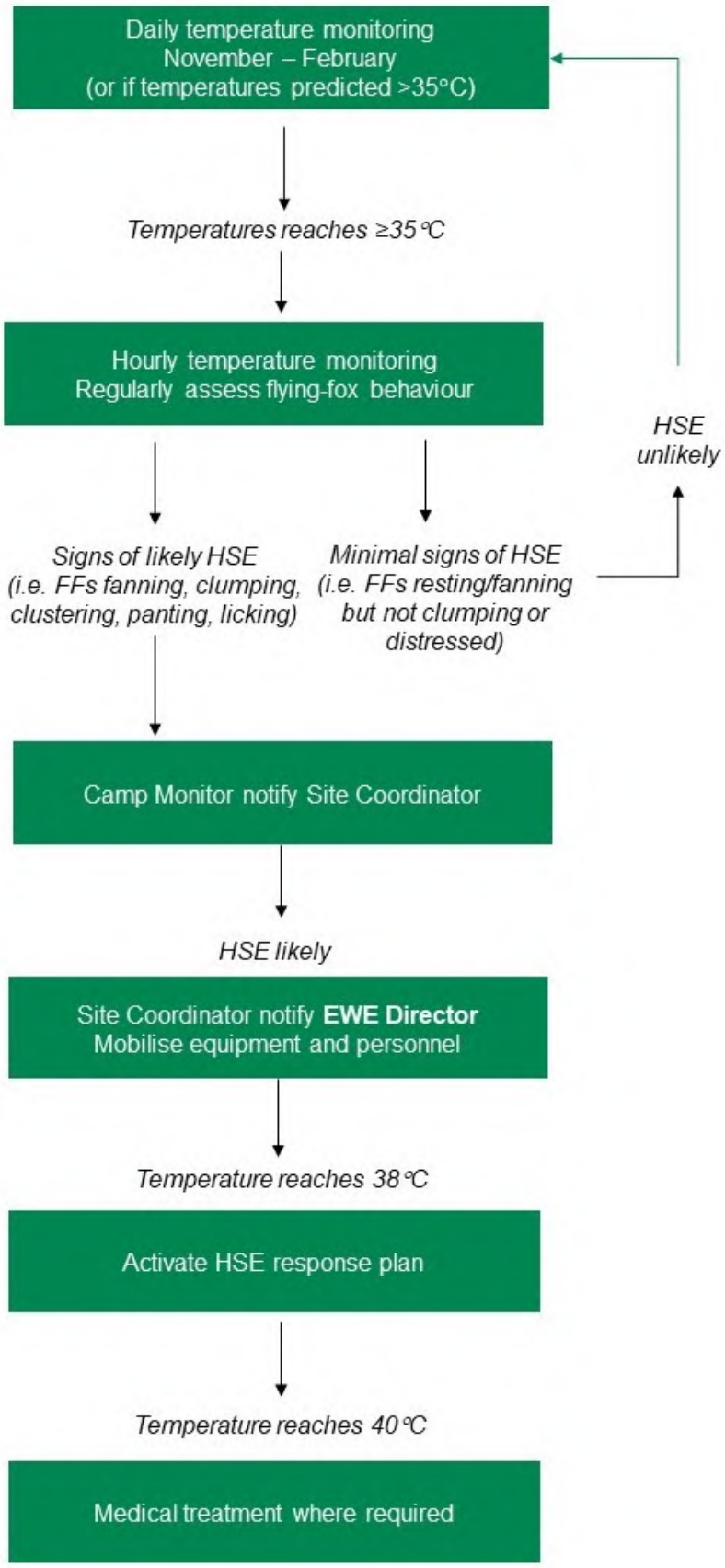

Figure 2 Process from camp monitoring to treatment. N.B. Events with large crowds and heat-generating equipment may increase the on-site temperature and monitoring thresholds may need to be reduced during events.

2.2.3 Contacts

A list of vaccinated rescuers, veterinarians and other resources is provided in Table 3. It should be noted that although ACT Wildlife are the primary responders to flying-fox emergencies because of their knowledge and mandatory ABLV vaccinations, these personnel are volunteers acting for and on land owned and managed by NCA.

Table 3 Contacts

Organisation	Name / title	Contact
ACT Wildlife	Denise Kay Flying-fox coordinator	0467 506 167
ACT Wildlife	Head office	0432 300 033
Wildcare Queanbeyan	Head office	6299 1966
ACT Government	Kyeelee Driver Biosecurity Veterinary Officer	0437 918 935 Kyeelee.Driver@act.gov.au
Animal Referral Hospital Fyshwick (vaccinated vets)	Dr Jacob Michelsen Specialist Small Animal Surgeon	6280 6344 (24hrs)
Brudine Vet at Charnwood		6258 1664
Kippax Veterinary Hospital		6255 1242
Parkway Kambah		6231 5129
Mugga Lane Landfill		13 22 81
Citywide	Matt Reid	0400 505 670 Matthew.Reid@citywide.com.au

2.3 Equipment

Equipment required to effectively manage a HSE is shown in Table 4, including who will supply these resources. A wash station and first aid kit will need to be provided in case of a flying-fox bite/scratch. This may or may not be the public toilets depending on events and the number of public present. The CP camp may benefit from sprinklers to reduce ground-level temperatures, and dehydration of flying-foxes in the upper canopy (N.B. careful intervention and monitoring is required to ensure HSEs are not inadvertently exacerbated - see Section 3.2). Appendix 1 illustrates locations of taps for sprinklers in Rhododendron Gardens.

2.4 Habitat restoration

Habitat restoration or vegetation modification under a camp requires a strategic approach. The ability for flying-foxes to move into the midstorey to seek cooler temperatures is an important feature and should be considered when selecting species for planting. Removing understorey vegetation such as weeds could compromise a colony's ability to survive during a HSE and therefore should be staged to allow the colony to move within the camp area.

Table 4 Resources and suppliers

Resource	Supplier		
	Rescuer	NCA	Veterinarian
PPE			
hat	✓		
long sleeves and pants	✓	✓	
closed shoes	✓	✓	✓
puncture-resistant gloves (e.g. welding gloves)	✓	✓	✓
sunglasses or protective eyewear	✓	✓	✓
insect repellent	✓	✓	
face masks when collecting bodies		✓	
Rescue equipment			
transport cages	✓		✓
poles and nets	✓		✓
spraying equipment			
sprinklers and hoses		✓	
First aid - human			
first aid kit		✓	
wash station		✓	
water bottle / drinking water	✓	✓	✓
First aid – flying-fox			
triage tent / table		✓	
towels	✓		✓
syringes			✓
fluids and other veterinary supplies			✓
garbage bags for disposal		✓	
tongs for handling carcasses		✓	
zip ties		✓	
Communication			
mobile phones	✓	✓	✓
safety plan with contact details		✓	
Record sheet	✓	✓	
Induction sheet	✓		

3 Response

3.1 Mobilise personnel and equipment

When temperatures reach 35ºC, camp monitors need to be onsite observing flying-fox behaviour. Temperature and humidity should be monitored each hour. Camp monitors to liaise with the Site Coordinator who will recommend to the EWE Director (NCA) the need to mobilise the response by 38ºC.

Table 5 Flying-fox behaviour during HSE (adapted from: Bishop et al. 2019 Stanvic et al. 2013).

Stage	Bat behaviour	Action	Category
Resting	Hanging from perch, wings wrapped around body, eyes closed	No action required	1
Wing fanning	Movement of wings in steady fanning motion may start at temperatures as low as 23ºC	Do not approach Continue to observe	2
Clustering	Bats start to move further down the trees into middle storey vegetation Includes wing fanning	Do not approach Continue to observe Call Site Coordinator to mobilise team	3a
Clumping	Individuals moving in proximity of each other May appear hyperactive or distressed	Observe from a distance so as not to disturb unnecessarily HSE response personnel should be in place and ready to respond	3b
Panting	Rapid breathing with mouth open	Observe and prepare	3b
Licking wrists	Individuals licking wrists or wing membranes	Observe and prepare	3b
Signs of heat stroke begin			
Moving down from canopy	Clumping in the understorey Clumping at base of trees or on the ground Clumping under logs or in tree hollows	Directly spray animals if disturbance to the camp can be avoided, and monitor (note spraying may not be appropriate on high humidity days) Even when in the understorey and base of trees, bats are capable of responding to spraying and can return to the canopy when conditions cool back down	4
Bats on ground or having seizures	Flying-fox on ground, lethargic	Report to site coordinator/vet Collect and take to first aid tent	4
Flying	Flying aimlessly, colliding with trees	Retreat – do not waste flying-fox energy or risk mothers dropping young	
Falling to the ground	Disorientated	Leave unconscious bats If juveniles are attached to deceased mothers, they will need to be removed by carers	
Death	Unresponsive	Collect if disturbance to remaining camp can be minimised OR Leave and collect at night	

3.2 Observe and respond

3.2.1 When to turn on sprinklers

Operation of the sprinklers can only be done with prior approval by the NCA. Water sprinklers may be set up under the camp (in Rhododendron Garden) at night prior to a predicted HSE or by camp monitors, preferably before temperatures reaches 35ºC (M. Jeffrey, 2020 pers. comm. 5 June). Sprinklers are intended to cool the lower canopy area where flying-foxes will retreat during a HSE.

- Established that majority of the colony (>70 %) are exhibiting category 3 & 4 behaviours and the need for response has been confirmed.
- On days predicted by BOM to reach or exceed 40ºC, sprinklers can be turned on.
- When temperatures have reached 35ºC the sprinklers can be activated for a maximum of 10 minutes per hour at each station.
- When temperatures have reached 38ºC the sprinklers can be activated for a maximum of 12 minutes per hour at each station.
- When temperatures have reached 40ºC or above the sprinklers can be activated for a maximum of 15 minutes per hour at each station.

Do not turn on sprinklers if humidity is predicted to reach more than 70%. Carefully monitor flying-fox behaviour to ensure HSE effects are not being exacerbated by intervention.

3.2.2 When to hand spray

If there are water restrictions, use spray bottles that allow personnel to maintain a minimum distance of 1-2 metres (Stanvic et al. 2013) from flying-foxes. Direct spray 3 times with 15-minute intervals. Do not mist if humidity is high (>70%).

3.2.3 When to collect flying foxes

Do not touch flying-foxes without appropriate PPE. Only vaccinated and trained people should rescue flying-foxes.

After three (3) attempts at spraying, remaining bats that have not responded (e.g. climbing back into the mid-storey) may be taken for triage. Do not immediately remove young flying-foxes that appear orphaned, as mothers will often come back for babies once the situation has settled. The triage process at Headquarters is determined by the Veterinarian with the Site Coordinator using the Flying-fox Heat Event Response Guidelines (Bishop et al. 2019) as a guide. Caution must be taken when approaching flying-foxes to avoid further stress.

3.3 Data collection

All flying-foxes brought into triage should be catalogued and mortality recorded on data sheets to be made available to NCA.

Data recording sheets (e.g. the Western Sydney University Animal Lab data form for HSEs) should be available at the headquarters or induction point during a HSE.

4 Post-event recovery

4.1 Carcass disposal

All bats should be viewed as potentially carrying ABLV. If disposing of a dead flying-fox, do not directly touch it, use a shovel or tongs and place into two plastic bags.

Dead bodies should only be collected by ABLV vaccinated people and with appropriate PPE.

Carcasses should be dropped at a registered landfill site.

4.2 Reporting

ACT Wildlife has existing protocols for reporting including for HSEs where data is entered on the Flying-fox heat stress forecaster: https://www.animalecologylab.org/ff-heat-stress-forecaster.html.

Data sharing arrangements may be agreed in an MOU. Until this time NCA will seek copies of ACT Wildlife's data and records taken during EWEs.

4.3 Debrief

Attending a flying-fox camp during an extreme weather event can be very stressful. NCA EWE Director should organise a debrief for all personnel involved as soon as convenient after the event to identify support that may be required, reflect on the process and find efficiencies for the next event.

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Appendix 1 Water source location (Source: ACT Wildlife 2020)

Three·of·these·look·like·ordinary·garden·taps·and·the·other·is·a·blue·

Appendix 2 Example induction/sign in sheet

I have read the EWE response plan and understand the responsibilities of my allocated role and agree to follow instructions given by the Site Coordinator.

I have brought or been provided with appropriate PPE to participate in the HSE response. Those personnel who are not vaccinated, are not required to enter the camp and if they do, do so at their own risk.

I have provided my contact details and vaccination status contact to the Site Coordinator.

Name	Organisation	Phone No.	Date	Vaccinated Y/N	Time in	Time out

Revision History

Revision No.	Revision date	Details	Prepared by	Reviewed by	Approved by
00	23/06/2020	Extreme weather event response plan	Emily Hatfield Senior Wildlife Biologist	Jess Bracks Principal Wildlife Biologist	James Davis, Wildlife Team Manager

Distribution List

Copy #	Date	Type	Issued to	Name
1	23/06/2020	Electronic	National Capital Authority	Michelle Jeffrey
2	23/06/2020	Electronic	Ecosure	Administration

Citation: Ecosure, 2020, *Extreme weather event response plan*, Report to National Capital Authority, Ecosure, Burleigh Heads

Report compiled by Ecosure Pty Ltd

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PR4557v1-Extreme Weather Event Response Plan

Cover photo: Grey-headed flying-fox after belly-dipping (photo credit: Nick Edard)

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P 02 5621 8103

Gladstone
PO Box 5420
Gladstone QLD 4720
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Gold Coast
PO Box 404
West Burleigh QLD 4219
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Sunshine Coast
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Appendix 3 GIS methods

a. Methods for modelling potential flying-fox habitat

A potential flying-fox roost habitat map was created using a predictive GIS-based model based on habitat suitability and known selection preferences of flying-fox for certain environmental attributes.

i. Data acquisition and review

Datasets were sourced from the ACT, Geoscience Australia and AusCover public data portals and reviewed for suitability in terms of spatial resolution, consistency, extent, age and reliability. The final datasets used for modelling and mapping of potential camp habitat are listed in Tables 1.

Table 1 Data used for modelling potential flying-fox roost habitat

Dataset name	Description	Source	Temporal relevance	Spatial resolution
Vegetation communities	Mapped vegetation communities of the Australian Capital Territory (ACT)	NCA (2019)	2013	-
Water feature polygons	Water features mapped as areas (polygons) including rivers, creeks, lakes, swamps and dams	NCA (2019)	2019	-
Water feature lines	Water features mapped as lines including rivers and creeks	OEH (2019)	2019	-
NSW woody vegetation extent	A map of woody vegetation presence or absence, where woody vegetation is defined as trees and shrubs taller than two metres and visible at the resolution of the imagery used in the analysis (5 m by 5 m pixels)	TERN AusCover (2011)	2011	5 m x 5 m
NSW Woody foliage projective cover (FPC)	FPC is the fraction of the ground that is obscured by green leaf, and is a measure of density	TERN AusCover (2011)	2011	5 m x 5 m
DEM derived from LiDAR 5m Grid	The Digital Elevation Model (DEM) 5 Metre Grid of Australia derived from LiDAR model represents a National 5 metre (bare earth) DEM – used to derive slope as an input to the habitat model	Geoscience Australia (2019)	2015	5 m x 5 m
Territory plan land use zones polygons	Land use zoning within the ACT	NCA (2018)	2018	-

ii. Data preparation

Data were prepared and processed using ESRI ArcMap 10.4 and Spatial Analyst extension. The model analysis area comprised a 20km radius surrounding the flying-fox camp at Regatta Point in the Commonwealth Park, Canberra. Analysis was carried out at a spatial resolution of 5 m x 5 m (determined by the data layer(s) with the coarsest spatial resolution). Once each dataset had been quality-checked, all data were projected to the GDA94_MGA_zone_55

datum and coordinate system. A list of the model variables used for mapping potential flying-fox camp habitat are described in Table 2.

Table 2 Summary of model variables used for mapping potential camp habitat

Feature	Implications for site selection
Vegetation type	Sites dominated by favoured vegetation species
Roost tree height	Vegetation communities containing trees greater than 5 m selected
Alternative food resources	Proximity to supplementary resources (such as botanic gardens, residential and street trees, etc.) included using proximity to urban areas as a proxy
Distance to urban areas	Proximity to urban areas, with sites closest being more highly scored.
Proximity to water	Sites within 500 m of watercourses are preferred, with those within 200 m having higher priority
Slope	Flat sites preferred

iii. Model parameters

Based on the parameters mentioned in Table 2, scores were derived as tabulated in Table 3. Each parameter and its scoring is discussed in further detail below.

Table 3 Scoring values for habitat attributes

Score	Proximity to water	Potentially suitable vegetation*	Preferred vegetation (based on current camps) (empirical)	Height (m)	Foliar cover/foliage density (%)	Distance to urban area	Slope
0	>500 m	Conditional mask Y/N	All vegetation classes not appearing in known camps		<50%	>5 km	>15° incline
1	400 – 500 m		Vegetation classes known to occur in < 3 camps within the ACT & NSW region	< 10 m		1-5 km	10-15° incline
2	300 – 400 m		Vegetation classes known to occur in ≥ 3 camps within the ACT & NSW region		50 – 55%	300 m - 1 km	5-10° incline
3	200 – 300 m					0 – 300 m (score 4)	Flat - 5° incline
4	< 200 m			≥ 10 m	≥ 55%	Within urban area (score 8)	

1. Identification of preferred vegetation

Presence of suitable roost vegetation

Vegetation communities within the 2013 NCA Vegetation Communities layers were reviewed and selected based on characteristics used as selective preference by flying-foxes, such as presence of relevant tree species within the community, complexity of structure, likely presence of mid-storey, density, etc using attributes available within the spatial data. Selected communities were used to create a mask of 'suitable vegetation'. Any communities not considered suitable were excluded from the analysis (e.g. heathlands and grasslands) (see Table 4 for list of selected communities).

A major challenge associated with the modelling of potential camp habitat was the identification and evaluation of vegetation within urban open space and developed areas. None of the available vegetation mapping layers included small and/or regrowth vegetation patches (native or non-native) within urban areas. This posed a problem with regards to scoring vegetation based on flying-fox preference within these areas, especially as flying-foxes have been shown to prefer vegetation within transformed urban landscapes (Timmiss 2017). Therefore, to further refine the mask of 'suitable camp vegetation' a combination of the SPOT-derived AusCover woody vegetation extent and woody foliage projective cover (FPC) layers were used (TERN AusCover 2011). The AusCover woody vegetation extent layer shows the presence or absence of woody vegetation, where woody vegetation is defined as trees and shrubs taller than two metres and visible at the resolution of the imagery used in the analysis (5 m by 5 m pixels), making it possible to mask out non-woody vegetation. However, on its own the woody vegetation extent showed some confusion between true woody vegetation and other features which shared similar spectral properties (e.g. grass in shade and some sections of road). The woody FPC, which is the fraction of the ground that is obscured by green leaf, provides a measure of foliage density making it possible to both mask out areas of very low foliage density and to score more highly those patches of suitable woody vegetation which had dense foliage. FPC values below 42% cover were masked out; woody vegetation with cover of 42 to 50% received a score of '0'; 50-55% received a score of '2' and cover ≥55% received a score of '4'.

Preferred vegetation

To take into account empirical observations of flying-fox selection of specific vegetation types, an analysis was carried out where a set of 185 buffered grey-headed flying-fox camp locations within the greater NSW and ACT regions were intersected with the 2017 NSW 5m vegetation mapping to determine the frequency of occurrence of vegetation classes at known camps (the field 'Class' in this mapping layer corresponds directly with the 'Class' field within the ACT Vegetation Communities mapping). Vegetation preference was evaluated and scored based on the resultant statistics, which showed that 52% of camps occurred in 'Cleared' (noting this category includes non-remnant vegetation such as urban parks), 'Subtropical Rainforests' and 'Coastal Swamp Forests' vegetation classes. After that 26% of camps occurred in 'Coastal Floodplain Forests', 'Mangrove swamps', 'North Coast Wet Sclerophyll Forests', 'Northern Warm Temperate Rainforests' and 'Northern Hinterland Wet Sclerophyll Forests'. The remaining 22 vegetation classes comprised 21% of camps. Of the 78 classes which occurred across the region covered by the camp data, only 3 occur within the analysis area of this study, namely Eastern Riverine Forests, Inland Riverine Forests and Southern Tableland Dry

Schlerophyll Forests, each of which occurred in 6, 4 and 1 camps, respectively. Based on the demonstrated preference of flying-foxes for each of these vegetation types, the scores of preferred vegetation classes were weighted to reflect within the model this preference. Thus, the most frequently selected classes scored '2', the second most frequently selected classes scored '1' and the remaining classes were scored '0' (Table 4). Vegetation classes identified as being not 'suitable' for flying-foxes were not included in this analysis. Similarly, areas devoid of vegetation that were also classified as 'cleared' were excluded by masking with the woody vegetation layer (discussed previously).

Table 4 Classification of ACT vegetation communities into potential flying-fox habitat with associated scoring

Vegetation Community	Vegetation Class	Likely FF habitat?	Score
Alpine Ash - Mountain Gum / Snow Gum wet sclerophyll open forest_u239	Montane Wet Sclerophyll Forests	YES	0
Amenity planting exotic_APE	-	YES	0
Amenity planting native_APN	-	YES	0
Apple Box - Broad-leaved Peppermint tall shrub-grass open forest primarily on granitoids_u29	Southern Tableland Dry Sclerophyll Forests	YES	1
Arboriculture_ARB	-	YES	0
Black Cypress Pine - Brittle Gum tall dry open forest on hills_u191	Southern Tableland Dry Sclerophyll Forests	YES	1
Black Sallee grass-herb woodland in drainage depression and moist valley flats_u118	Subalpine Woodlands	YES	0
Black She-oak - Silvertop Ash tall shrubby dry sclerophyll open forest_p10	Southern Tableland Dry Sclerophyll Forests	YES	1
Blakely's Red Gum - Yellow Box tall grassy woodland_u19	Southern Tableland Grassy Woodlands	YES	0
Broad-leaved Peppermint - Brittle Gum - Red Stringybark tall shrub-grass dry sclerophyll open forest of lower ranges_u105	Southern Tableland Dry Sclerophyll Forests	YES	1
Broad-leaved Peppermint - Candlebark tall dry sclerophyll open forest of quartz-rich ranges_u21	Southern Tableland Dry Sclerophyll Forests	YES	1
Broad-leaved Peppermint - Mountain Gum shrubby tall open forest_u150	Southern Tableland Dry Sclerophyll Forests	YES	1
Derived native forest_DNF	-	YES	0
Derived native shrubland_DNS	-	YES	0
Derived native woodland_DNW	-	YES	0
Drooping She-oak low woodland to open forest on shallow infertile hillslopes in the Australian Capital Territory and surrounds_q1	Southern Tableland Dry Sclerophyll Forests	YES	1
Environmental planting native_EPN	-	YES	0
Exotic forest_EXF	-	YES	0
Exotic woodland_EXW	-	YES	0
Jounama Snow Gum - Snow Gum shrubby mid-high woodland on granitoids primarily of the Namadgi region_u207	Subalpine Woodlands	YES	0
Mealy Bundy - Broad-leaved Peppermint shrubby mid-high open forest on granite substrates_u18	Southern Tableland Dry Sclerophyll Forests	YES	1

Vegetation Community	Vegetation Class	Likely FF habitat?	Score
Mealy Bundy - Red Stringybark grass-forb mid-high open forest_u66	Upper Riverina Dry Sclerophyll Forests	YES	0
Mountain Gum - Blackwood tall wet sclerophyll open forest primarily on granitoids_u53	Montane Wet Sclerophyll Forests	YES	0
Mountain Gum - Snow Gum / Robertson's Peppermint grass-forb very tall woodland to open forest_u22	Subalpine Woodlands	YES	0
Mountain Plum Pine - Kosciuszko Rose heathland of screes and boulder-fields_a54	Alpine Heaths	YES	0
Red Box tall grass-shrub woodlands primarily on hillslopes and footslopes in the Australian Capital Territory_q6	Southern Tableland Grassy Woodlands	YES	0
Red Stringybark - Broad-leaved Peppermint tall dry sclerophyll grassy open forest on loamy rises_p23	Southern Tableland Dry Sclerophyll Forests	YES	1
Red Stringybark - Scribbly Gum - Red-anthered Wallaby Grass tall grass-shrub dry sclerophyll open forest on loamy ridges_p14	Southern Tableland Dry Sclerophyll Forests	YES	1
Ribbon Gum - Robertson's Peppermint very tall wet sclerophyll open forest_u52	Southern Tableland Wet Sclerophyll Forests	YES	0
Ribbon Gum very tall woodland on alluvial soils along drainage lines_p520	Tableland Clay Grassy Woodlands	YES	0
River Bottlebrush - Burgan rocky riparian tall shrubland_u181	Eastern Riverine Forests	YES	2
River Red Gum / Apple Box very tall grass-forb riparian woodland on alluvial flats_u173	Inland Riverine Forests	YES	2
River She-oak riparian forest on sand-gravel alluvial soils along major watercourses_p32d	Eastern Riverine Forests	YES	0
Robertson's Peppermint - Red Stringybark very tall grass-forb sheltered open forest_u152	Southern Tableland Dry Sclerophyll Forests	YES	1
Robertson's Peppermint very tall shrubby open forest_u165	Southern Tableland Dry Sclerophyll Forests	YES	1
Snow Gum - Candlebark tall grassy woodland_u27	Subalpine Woodlands	YES	0
Snow Gum - Drumstick Heath - Myrtle Teatree tall woodland to open forest of drainage depressions_u23	Subalpine Woodlands	YES	0
Snow gum - Mountain gum - Daviesia mimosoides tall dry grass-shrub subalpine open forest_u28	Subalpine Woodlands	YES	0
Snow Gum grassy mid-high woodland_u78	Tableland Clay Grassy Woodlands	YES	0
Urban and developed areas_URB	Cleared / non-remnant vegetation	YES	2
Urban Open Space_UOS	Cleared / non-remnant vegetation	YES	2
Yellow Box / Apple Box tall grassy woodland_u178	Southern Tableland Grassy Woodlands	YES	0

Vegetation Height

Flying-foxes selectively roost in vegetation which is greater than 5 m in height (Roberts 2005). As the NCA Vegetation Communities layer includes estimates of height within the attributes it was possible to include vegetation height as a separate variable within the potential habitat model. In the model, tall, emergent trees were weighted more heavily than shorter vegetation. This was achieved using the Vegetation Communities mapping. Communities with a maximum height of <5m was masked out, while vegetation with a maximum height of <10m was given a score of '1' and that of ≥10m was given a score of '4'.

2. Proximity to water

Proximity to water is an important attribute in camp location (Hall & Richards 2000) with one study suggesting that 94% of grey headed flying-fox camps in NSW were (at that time) located adjacent to or on a waterway or waterbody (Eby 2002). Roberts (2005) reported that all 40 camps were located within 200 m of a drainage line. Peacock (2004) found that all of the 44 sites surveyed were located within 600 m of a watercourse, however many of these were dry at the time of survey, suggesting that the watercourse, and possibly broader topographical features, may act as navigational aids for flying-foxes (Roberts 2005, Hall & Richards 1991).

To include these preferences in the model, waterways such as river and creeks, as well as other water bodies (e.g. swamps, lakes and dams) were identified using the ACT water feature mapping. Distances to these water sources were scored as follows: <200m (score = 4); 200-300m (score = 3); 300-400m (score = 2); 400-500m (score = 1); and >500m (score = 0).

3. Distance to urban area

Studies have shown an increasing tendency for flying-foxes to roost in urban areas (Eby & Lunney 2002, Williams et al. 2006, van der Ree 2006). More recently, Timmiss (2017) demonstrated that nearly three quarters of grey-headed, black and little-red flying-fox (GHFF, BFF, LRFF) camps across Australia are in urban areas (72%, 73% and 69% respectively). However, it has been argued that while GHFF are roosting in urban areas, they still prefer to feed in non-urban areas (Roberts 2013).

For the current analysis, urban centres were defined using selected land zones of the ACT plan land use zones layer (Table 5).

Based on current research findings discussed above, the scoring of distance to urban areas is as follows: within urban area (score = 8); 0-300 m (score = 4); 300 m-1 km (score = 2); 1-5 km (score = 1); and >5 km (score = 0).

Table 5 Land zone classes used to define urban centres

Land use zones
Business zone
Community facilities
Core zone
Designated
General industry

High density residential
Industrial mixed use
Leisure and accommodation
Local centre
Medium density residential
Mixed use
Restricted access recreation zone
Services
Services zone
Suburban
Suburban core
Transport
Urban open space
Urban residential

4. Slope

Landscape features identified as being 'typical' of camp sites include a level site or one with less than 5˚ incline (Eby 2002; Peacock 2004; Roberts 2005) or gullies (Roberts 2005). However, while flying-foxes seem to prefer flat topography, they will utilise suitably vegetated gullies along water courses. Slope was scored as follows: flat to 5 degree incline (score = 3); 5-10 degree incline (score = 2); 10-15 degree incline (score = 1); and >15 degree incline (score = 0).

iv. Determination of potential camp habitat

Once the attributes within each input dataset had been processed and scored (as per Table 2), the ESRI Spatial Analyst raster calculator was used to sum up the scores across each input layer. The resultant raster data output produced a spatially distributed range of values representing levels of potential for roost habitat. Score thresholds were determined to classify the final summed score into classes of low, medium and high potential habitat.

v. Limitations

Temporal relevance of data – the model output represents a point in time when the input layers were mapped e.g. imagery used to develop the woody vegetation extent and FPC layer were acquired during the period 2008 to 2011 and the Vegetation Community layer was mapped in 2012, making these data inputs relevant to those time periods. Vegetation is dynamic in nature and its attributes can vary from one year to the next and one season to the next. This may result in the model over or under predicting the presence of high-quality flying-fox habitat. Furthermore, due to vegetation clearing, the model may over-estimate the presence of potential flying-fox habitat in areas where suitable habitat has been cleared.

Care should be taken when interpreting the woody vegetation extent maps. Incorrect classification is most likely to occur where it is difficult to distinguish trees greater than two metres in height from other types of vegetation. Such vegetation includes sparse woodlands, low shrubs, chenopods, heath, wetlands, and irrigated pastures and crops. Also, woody

vegetation is only detected about half of the time when the foliage cover within a pixel is less than 20%. While every effort was made to compensate for this, inaccuracies may still affect model outputs, causing either over or under predictions of high-quality habitat.

Vegetation community data layer – vegetation attributes are represented by homogeneous polygons. Actual distribution of resources which attract flying-fox to a potential roost area (such as density and condition of certain tree species, vegetation height, presence and density of mid-storey, etc) are likely to be patchy within a mapped area. Therefore, while the model may predict large contiguous areas as being uniformly attractive to flying-foxes, the reality is flying-foxes may only be attracted to specific localities within the broader vegetated area based on variations of habitat quality not represented by the data. As a result, predictions of high-quality roost habitat may be over predicted.

No species information regarding vegetation within the urban developed areas or urban open spaces was available. While attributes such as vegetation height and canopy density etc are provided in the Vegetation Community data, these are generalised to the polygon level, which is not a true representation of reality.

Appendix 4 Dispersal summary

Roberts and Eby (2013) summarised 17 known flying-fox dispersals between 1990 and 2013, and made the following conclusions:

1. In all cases, dispersed animals did not abandon the local area.
2. In 16 of the 17 cases, dispersals did not reduce the number of flying-foxes in the local area.
3. Dispersed animals did not move far (in approx. 63% of cases the animals only moved <600 m from the original site, contingent on the distribution of available vegetation). In 85% of cases, new camps were established nearby.
4. In all cases, it was not possible to predict where replacement camps would form.
5. Conflict was often not resolved. In 71% of cases conflict was still being reported either at the original site or within the local area years after the initial dispersal actions.
6. Repeat dispersal actions were generally required (all cases except where extensive vegetation removal occurred).
7. The financial costs of all dispersal attempts were high, ranging from tens of thousands of dollars for vegetation removal to hundreds of thousands for active dispersals (e.g. using noise, smoke, etc.).

Location	Species	FF population estimate at time of dispersal	Method	Did the animals leave the local area?	Did the local population reduce in size?	How far did they move?	Were new roosts formed (number of new roosts if known)?	Number of separate actions	Cost (if known)	Was conflict resolved at the original site?	Was conflict resolved for the community?
Barcaldine, Qld	R	>50,000	VN	no	no	≈2 km	yes (1)	trees in township felled		yes	no
Batchelor, NT	B	200	BNS	no	no	<400 m	yes (1)	2		yes	yes
Boyne Island, Qld	BR	25,000	LNS	no	no	<500 m	yes (2)	3		yes	no

Location	Species	FF population estimate at time of dispersal	Method	Did the animals leave the local area?	Did the local population reduce in size?	How far did they move?	Were new roosts formed (number of new roosts if known)?	Number of separate actions	Cost (if known)	Was conflict resolved at the original site?	Was conflict resolved for the community?
Bundall, Qld[1]	GB	1580	V	uk	no	uk, but 7 roosts were within 5	no	1	$250,000	yes	yes
Charters Towers, Qld	RB	variable	HLNPOW	no	no	200 m	no (returned to original site)	repeated since 2000	>$500,000	no	no
Dallis Park, NSW	BG	28,000	V	no	yes	300 m	yes (1)	2		yes	no
Duaringa, Qld	R	>30,000	VNFO	no	no	400 m	yes	1	$150,000	yes	uk
Gayndah, Qld	RB	200,000	VN	no	no	600 m	yes	3 actions, repeated		yes	no
Maclean, NSW	BGR	20,000	NS	no	no	350 m	yes (7)	>23	>$400,000 and ongoing	no	o
Mataranka, NT	BR	>200,000	BHLNOSW	no	no	<300 m	uk	>9		no	no
North Eton, Qld	B	4800	VNFB	uk	no	<1.5 km initially	yes (≈4 majority temporary)	2	45,000	yes	yes (conflict at one site)
Royal Botanic Gardens, Melbourne, Vic	G	30,000	NS	no	no	6.5 km	yes (2)	6 mths	$3 million	yes	yes, ongoing management required
Royal Botanic Gardens, Sydney, NSW	G	3,000	LNPOW	no	no	4 km	no	ongoing daily actions for 12 mths	>$1 million and ongoing	yes	yes

[1] Bundall information amended from Roberts and Eby (2013) based on Ecosure's direct involvement and understanding of roost management activities and outcomes.

Location	Species	FF population estimate at time of dispersal	Method	Did the animals leave the local area?	Did the local population reduce in size?	How far did they move?	Were new roosts formed (number of new roosts if known)?	Number of separate actions	Cost (if known)	Was conflict resolved at the original site?	Was conflict resolved for the community?
Singleton, NSW	GR	500	LNUW	no	no	<900 m	no (returned to original site	>3	$117,000 and ongoing	no	no
Townsville, Qld	BR	35,000	BNS	no	no	400 m	no (returned to original site)	5		no	no
Warwick, Qld	GRB (dispersal targeted R)	200,000	NLBP	no	no	≈1 km	no (site known to be previously occupied by GB)	5 days	$28,000	yes	uk (complaints persisted until migration)
Young, NSW	R	<5000	VN	no	no	<600 m	yes (1)	uk		yes	no

* G = grey-headed flying-fox; B = black flying-fox; R = little red flying-fox
# B = “birdfrite”; F = fog; H = helicopter; L = lights; N = noise; P = physical deterrent; O = odour; S = smoke; U = ultrasonic sound; V = extensive vegetation removal; W = water.
uk unknown

Appendix 5 Monitoring form

Camp	
Proposed activity	
Type of disturbance	
Level of risk	
Frequency (Dates to and from)	
Duration (Time)	
Proposed mitigation	
Monitoring required (Yes if high risk)	
Monitoring submitted to NCA	
Approved by NCA	
Supporting Photos/Maps	
Monitoring	
Date	
Time	
Assessors	
Weather conditions	
Grey-headed flying-fox	
Count	
Females visibly pregnant	
Dependent young	
Body condition	
Morbidity/ mortality	
Stress indicators	
Behavioural observations	
Roost extent	
Add boundary points	
% currently occupied	
% available suitable habitat	
Vegetation condition	

Appendix 6 Monitoring Program results

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FLYING-FOX MONITORING SUMMARY REPORT

November 2019 - May 2020

NATIONAL CAPITAL AUTHORITY

Acknowledgements

Ecosure would like to thank ACT Wildlife for provision of Commonwealth Park flying-fox data, Michelle Jeffrey (National Capital Authority) for organising access to the Park during organised events, and Citywide staff for their cooperation during monitoring and the hailstorm emergency response.

We also offer a heartfelt thanks to ACT Wildlife, ACT government and other responders following the severe hailstorm in January 2020. This would have been an extremely distressing event and we greatly appreciate your efforts.

Acronyms and abbreviations

ABS	Australasian Bat Society
BOM	Bureau of Meteorology, Australian Government
GHFF	Grey-headed flying-fox (*Pteropus poliocephalus*)
LRFF	Little red flying-fox (*P. scapulatus*)
NCA	National Capital Authority
NSW	New South Wales
the camp	Commonwealth Park flying-fox camp

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1 Introduction

National Capital Authority (NCA) commissioned the Commonwealth Park grey-headed flying-fox (*Pteropus poliocephalus*, GHFF) monitoring program in August 2019 (Ecosure 2019a). This report provides a summary of monitoring at Commonwealth Park flying-fox camp (the camp) from November 2019 to May 2020. The monitoring period was influenced by extreme weather events in Canberra and impacted by COVID-19 restrictions.

The 2019-2020 monitoring program aimed to gather data on flying-fox behaviour during:

- periods of rest (i.e. without disturbance)
- periods of potential stress
- during park operations and events.

It was envisaged these data could:

- be compared with noise emission data collected by qualified noise consultants
- assist in determining which operations or events represent a risk to flying-fox welfare
- assist in determining appropriate levels of mitigation or management.

This summary report includes data provided in 'Acoustic Data for Grey-headed Flying-fox Monitoring' (WSP 2020) and 'Post-Hail Report' (ACT Wildlife 2020).

1.1 Environmental conditions

Between 2019 and 2020, flying-foxes experienced a range of environmental weather events. A prolonged drought period (BOM 2020a) caused a mass food shortage from Coffs Harbour to Gladstone, in which thousands of flying-foxes perished from starvation (ABC News 2019a). Wildlife care groups reported a high number of calls of dead and starving flying-foxes as well as many females not bearing pups – a possible indication of early abortions or insufficient nutrition (ABC News 2019). These findings are significant for the Commonwealth Park camp because the GHFF population is considered to be one single national population due to their wide-ranging movements (Eby 1991, Tidemann and Nelson 2004).

Canberra's 2019-2020 summer recorded four days over 40ºC (the temperature at which flying-foxes begin to suffer heat stress) with the highest temperature reaching 44ºC on January 4 (Station 70351, BOM 2020a; Bishop et al. 2019). Catastrophic bushfires across the east coast of Australia that subjected Canberra to weeks of lingering smoke (ABC News 2019b), destroyed large tracts of flying-fox foraging habitat across the GHFF range.

On January 20, 2020, the camp was struck by a severe hailstorm resulting in 344 GHFF deaths (including 260 euthanased due to injury). In the two weeks following there were a further 296 deaths related to the hailstorm including orphaned and injured flying-foxes (ACT Wildlife 2020), totalling at least 640 deaths related to this single event.

Interestingly, several little red flying-foxes (*Pteropus scapulatus*, LRFF) were observed by ACT Wildlife amongst the GHFFs during rescue following the hail event (the first known record of LRFF at Commonwealth Park camp) (pers.obs. B. Wilson 2020).

1.2 Park operations and events

The monitoring program covered a range of activities and events in Commonwealth Park with the potential to disturb flying-foxes. Additional monitoring events were scheduled for the birthing and rearing period to better understand how activities in Commonwealth Park affect dependent young and mothers. Fourteen monitoring events were scheduled however only eight were undertaken due to a delay in starting the program due to seasonally low numbers (only 44 flying-foxes were recorded on 28 September) as well as COVID-19 restrictions causing cancellation of some events in 2020.

Table 1 Proposed versus actual monitoring events

Events	FF activity	Month	Monitoring allocated	Monitoring undertaken	Monitoring notes
Floriade	Final trimester	Sep	1	Nil	Program start delayed with seasonally low numbers
Floriade	Peak birthing	Oct	2	Nil	Program start delayed with seasonally low numbers
Spilt Milk	Peak birthing	Nov	2	Nil	Event access not permitted
Regatta Point Café construction	Peak birthing/ Crèche period	Nov	1	2	Background noise monitoring by WSP Park maintenance - tree fall
Carols by Candlelight	Crèche period	Dec	2	2	
Australia Day	Crèche period	Jan	1	1	
Floriade	Crèche period	Feb	1	1	Replaced Floriade monitoring with Cold Chisel concert
Presets and Paul Kelly concert	Crèche period	Feb	1	Nil	Monitoring cancelled
Skyfire	Peak conception	Mar	1	Nil	Event postponed due to COVID-19
Canberra Day	Peak conception	Mar	1	Nil	Cancelled due to COVID-19
Symphony in the Park	Peak conception	Mar	1	1	
Anzac Day	Peak conception	Apr	1	Nil	Cancelled due to COVID-19
Maintenance works	Pregnant females	May	Nil	1	
Total			14	8	

1.2.1 Access and stakeholder engagement

Ecosure monitors were denied access to the camp to monitor one major event by the event

organisers. All other events permitted access and were cooperative. An event organiser expressed concerns during the community engagement process for the Commonwealth Park Flying-fox Camp Management Plan (Ecosure 2019b) in August 2019. They believed the Management Plan as it stands provided little opportunity for mitigating action on behalf of the organisers.

Citywide staff have taken ownership of the camp's welfare, regularly communicating with NCA on park maintenance that may affect the flying-foxes, as well as cooperating in the gathering of data.

Figure 2 Flying-foxes were monitored during Carols by Candlelight

Figure 1 Flying-fox monitoring undertaken while park maintenance occurred on a fallen tree

2 Results summary

Ecosure Environmental Scientist undertook monitoring at the camp between November 2019 and May 2020.

2.1 Weather

Table 2 provides temperature and humidity for days on which event or maintenance monitoring occurred. The hottest day recorded in Canberra was 44ºC on January 4, 2020 (BOM 2020b).

Table 2 Weather conditions during monitoring events.

Event	Date	Max temp ºC	Humidity %	Other notes
Park maintenance - tree fall	4/11/2019	19	n/a	Intermittent rain
Park maintenance - tree fall	5/11/2019	25	n/a	Fine and sunny
Carols by Candlelight 1500	14/12/2019	28	23	Warm and windy
Carols by Candlelight 1930	14/12/2019	25	46	Breezy and mild
Australia Day	26/01/2020	37	n/a	Fine and sunny
Cold Chisel	30/01/2020	33	12	Hot, some smoke
Symphony in the Park	08/03/2020	20	n/a	Showers
Maintenance works	05/05/2020	17	n/a	Fine

2.2 Flying-fox counts

The peak number of flying-foxes recorded in the camp in March 2019 was 8,190. The 2020 peak to date was 4,765 (Figure 1), recorded on Australia Day. This much lower peak compared with the same period last year may be indicative of landscape changes and potential population impacts associated with severe weather events (e.g. fires, smoke, heat, storms) over the 2019-20 summer.

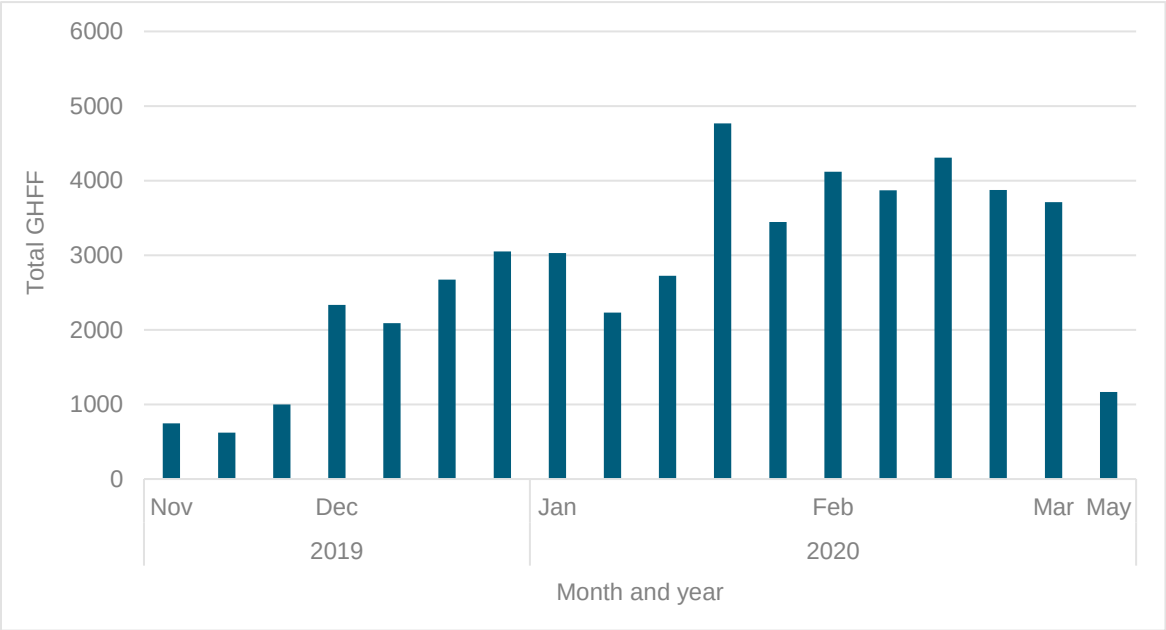

Figure 3 GHFF numbers during the monitoring period 2019-2020. Data were recorded by Ecosure and the Australasian Bat Society as part of their monitoring for the National Capital Authority and the ACT Government. No LRFF were observed during these monitoring events.

2.3 Flying-fox behaviour

Table 3 provides a summary of flying-fox behaviour during Park monitoring. For example, on 5 May 2020, Citywide trialled lawn mowing, chipping and chainsaw operations at various parts of the camp to determine the impact on the bats. Agitation and lifting seemed to be mostly localised within 50m of the stimulus (Ecosure observation).

Table 3 Flying-fox behaviour during monitoring

Event	Date	Count	Behavioural observations	Health
Park maintenance - tree fall	4/11/2019	746	Occasional wing fanning and flying, intermittent chatter. When the chipper, winch or chainsaw was started or running the bats were calm. However, after a large branch was cut, cracked and fell, mothers and other flying foxes from the closest tree to the felling lifted off and moved away to trees towards the epicentre of the camp.	Body condition good. No young abortion or abandonment observed.
Park maintenance - tree fall	5/11/2019	624	Quiet during count, agitation and lift off after lawn mower began between Stage 88 and camp.	Body condition good.
Carols by Candlelight 1500	14/12/2019	2,090	Mostly undisturbed by music, though some agitation (vocalising) as children played in the understory beneath them.	10 decaying pups on the ground.
Carols by Candlelight 1930	14/12/2019	2,088	Occasional fanning and chatter.	
Australia Day	26/01/2020	4,765	Constant chatter and occasional fanning between 0800 and 0935. At 0935 the 21-gun salute began as well as fighter jets flying low over Commonwealth Park. Over	Most good, some poor due to injuries from hailstorm on 20/1/2020 preventing fly-out.

Event	Date	Count	Behavioural observations	Health
			75% of the bats in the camp lifted off and were flying or agitated for up to 30 mins after salute ended. ~10% of camp relocated to trees outside the normal roost extent for the camp (i.e. to the north or far west of Stage 88, over the lake). Rate of injured hail affected bats falling from trees did not appear to increase after gun salute.	Due to hail-related injuries, 13 found deceased onsite, 24 euthanased, 3 orphaned pups taken into care.
Cold Chisel	30/01/2020	3,447	Flying-foxes did not appear agitated by Cold Chisel opening or main act but were constantly fanning and around 25% of individuals were roosting around the trunks or lower down the tree than usual. None observed in the understorey. Individuals were difficult to count due to heat stress clumping behaviour.	Several bodies observed in trees and ground (adults 2, juveniles 6), considered to be orphans or injured from hailstorm.
Symphony in the Park	08/03/2020	3,712	Relatively vocal and began fly-out at 1945 when the featuring act of Symphony in the Park began their first song.	Body condition good.
Maintenance works	05/05/2020	1,166	Lawn mower, chipper and chainsaw operation caused localised agitation and lift-off within 50m of the stimulus. After disturbance, flying-foxes expanded their use of the camp extent from 30 to 50% (were more spread out).	Body condition good.

Figure 4 Flying-fox reaction to 21-gun salute on 26 January 2020.

Figure 5 ACT Government veterinarian assisting ACT Wildlife with rescue and euthanasia of injured flying-foxes on 26 January, 6 days after the hail event.

2.4 Noise data

Seven noise monitoring events were undertaken by WSP (2020). Noise is unwanted, harmful or inharmonious (discordant) sound (WSP 2020) and can also be described as:

- continuous (e.g. factory equipment, engine noise, heating and ventilation systems)
- intermittent (e.g. train, aircraft)
- impulsive (e.g. demolition or construction)
- low frequency (NoiseNews 2020).

Flying-fox hearing sensitivity and vocalisations are in similar range to that of human hearing (Calford et al. 1985). Ambient or background sound levels at Commonwealth Park have an average sound level of 63 dB (Leq) and 52 dB (LAeq), with LA10 of 57 dB (WSP 2020 (Table 4). A normal conversation is about 60db and a lawn mower is about 90dB (Safe work Australia 2020).

Noise pollution is known to affect animal behaviour in a variety of species such as frogs and birds due to auditory signal masking (Brumm and Slabbekoorn 2005). Conversely, a study undertaken by Pearson and Clarke (2019) at several New South Wales (NSW) camps suggests that the way GHFF species communicates (e.g. loud vocalising in close proximity to one another) could account for its tolerance of current anthropogenic noise pollution levels in

urban habitats.

Noise monitoring has been carried out during construction projects near flying-fox camps in NSW. The Balgowlah and Burdekin Park camps tolerated construction noise impacts around 74 dBA (SLR Consulting 2017 in WSP & Parsons Brinckerhoff 2017) similar to the noise emitted from park maintenance activities in Commonwealth Park (Table 4). Similarly, the Clyde camp on the Duck River in Sydney occurs close to rail infrastructure and the camp is exposed to intermittent train passage events (Ecosure pers. obs.2020). At this camp, noise from the animals' own calls (57 dBA at 10 m) was louder than the environmental noise (51 dBA) (Pearson & Clarke 2019).

The noise monitoring results in Table 4 show that most flying-foxes at the Commonwealth Park camp were able to settle within 5-30 minutes of a noise event. As noise monitoring was unattended by scientists, it could not be determined whether the noise level drop after a noise-generating event was due to flying-foxes or the event itself. This is because flying-foxes are not likely to be present after fly-out around sunset. However, during daytime maintenance and Australia Day, noise drop figures are likely to demonstrate how long the flying-fox took to calm down after a noise generating event because flying-foxes are present in the camp during the day. This highlights the need to have flying-fox monitors observing the colony to cross reference noise with behaviour.

Table 4 Noise monitoring at the Commonwealth Park camp during park maintenance and events (Noise Data Source: WSP 2020)

Event	Date	Count	SOUND LEVEL dB				Minutes for noise level to drop (either FF or event) after sound event ended	Comments
			Average (Leq)	Average weighted (LAeq)	Exceeded 10% of time (L10)	Maximum (Lmax)		
Background noise monitoring	2019 Nov and Dec	~624-2090	63	52	68	72		General ambient noise.
Post tree-felling and lawn mowing	5/11/2019	624	75	63	71	80	10	Bats were quiet and calm during the count, then became agitated, lifted off and flew around the camp (30% bats) after lawn mower began between Stage 88 and camp at 1230.
Carols by Candlelight	14/12/2019	2088	93	76	97	104	30	Crowds, amplified music, and speech ended at 2115. Minutes for noise level to drop NOT likely related to flying-fox.
Australia Day	26/01/2020	4765	79	69	73	N/A	20	Crowds, amplified music, and speech ended 1335. Minutes for noise level to drop is likely related to flying-fox.
Cold Chisel	30/01/2020	3447	91	83	86	N/A	25	Crowds, amplified music, and speech finished at 2150. Minutes for noise level to drop NOT likely related to flying-fox.
Symphony in the Park	08/03/2020	3712	84	74	77	N/A	5	Crowds, amplified music, and speech finished at 2200. Minutes for noise level to drop NOT likely related to flying-fox. Flying-fox fly out 1745. Rain will impact noise logging (WSP 2020).
Park maintenance	05/05/2020	1166	74	64	67	N/A	20	Lawnmower and chipper 0850.
			70	58	62	N/A	15	Chainsaw 1025

3 Recommendations

In order for better understand the effects of noise and accumulative disturbance on flying-foxes in CP it is recommended to:

- continue the flying-fox and noise monitoring for at least one more season
- continue the flying-fox monitoring using weather data loggers within the camp
- collate the results of two years monitoring to inform ongoing management of the camp and events at CP.

Additional recommendations to help ensure flying-fox welfare and public safety includes:

- installing temporary fencing to exclude the area beneath the camp when injuries or fatalities may occur due to environmental factors (e.g. dead bats being on the ground and being touched by children at Carols by Candlelight)
- the installation of a misting system in the Rhododendron Garden to be used on days in excess of 35˚C.

4 Conclusion

Flying-fox numbers peaked at 4,765 during the 2019-2020 monitoring program. During this monitoring period, the Commonwealth Park flying-foxes were subjected to an extreme range of environmental weather events and conditions including widespread fires, smoke, heat events and a hail event that resulted in the loss of at least 640 GHFF from the camp.

Events such as the 21-gun salute on Australia Day and maintenance park activities produce a behavioural stress response from the flying-foxes. Results of the monitoring show flying-foxes were able to settle within around 30 minutes of a disturbance activity or event. It is recommended that a resting period of 10-15 minutes be provided between loud and sudden noisy park maintenance activities especially during vulnerable periods (i.e. breeding season or extreme weather events).

Flying-foxes behaviour during Cold Chisel recorded clumping and moving down the trees which indicated they were suffering from heat stress despite temperatures being around 33ºC. It is recommended for camp monitors to have weather data loggers to help determine whether ambient conditions of temperature and humidity within the camp differ to the data available on BOM or weather apps.

Flying-foxes like humans, appear most agitated by impulsive sound; sudden bursts that are fast or surprising in nature. Overall, the camp has some level of resilience to disturbances from regular park maintenance activities and events. However, the cumulative effects of sudden or unpleasant noise on flying-foxes has not been measured on flying-fox physiological stress, so the risk of temporary or permanent camp abandonment cannot be dismissed.

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Revision History

Revision No.	Revision date	Details	Prepared by	Reviewed by	Approved by
00	29/05/2020	Monitoring summary report Nov 2019-May 2020	Emily Hatfield Senior Wildlife Biologist	Jess Bracks, Principal Wildlife Biologist	James Davis, Wildlife Team Manager
01	08/06/2020	Monitoring summary report Nov 2019-May 2020.FI	Emily Hatfield Senior Wildlife Biologist		

Distribution List

Copy #	Date	Type	Issued to	Name
1	08/06/2020	Electronic	National Capital Authority	Michelle Jeffrey
2	08/06/2020	Electronic	Ecosure	Administration

Citation: Ecosure, 2020, *Monitoring Summary Report* Nov 2019 – May 2020, Report to National Capital Authority, Burleigh Heads

Report compiled by Ecosure Pty Ltd

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PR4557-DE.Monitoring summary report Nov 2019 to May 2020

Cover image: Grey-headed flying-fox (*Pteropus poliocephalus*) mother and pup, photo courtesy of Nick Edards

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Revision History

Revision No.	Revision date	Details	Prepared by	Reviewed by	Approved by
00	22/03/2013	Commonwealth Park Flying-fox Camp Management Plan	Emily Hatfield Senior Wildlife Biologist	Jess Bracks Principal Wildlife Biologist	James Davis, Wildlife Manager
01	8/05/2019	Commonwealth Park Flying-fox Camp Management Plan.R1		Peter Buetel, NCA Anna Wong, NCA Kathryn Tracy, ACT government Emily Hatfield, Senior Wildlife Biologist Jess Bracks, Principal Wildlife Biologist	James Davis, Wildlife Manager
02	17/05/2019	Commonwealth Park Flying-fox Camp Management Plan.R1		Peter Buetel, NCA Emily Hatfield, Senior Wildlife Biologist	Jess Bracks Principal Wildlife Biologist
03	6/11/2020	Commonwealth Park Flying-fox Camp Management Plan.FI	Emily Hatfield Senior Wildlife Biologist		

Distribution List

Copy #	Date	Type	Issued to	Name
1	6/11/2020	Electronic	National Capital Authority	Michelle Jeffery
2	6/11/2020	Electronic	Ecosure	Administration

Citation: Ecosure, 2019, *Commonwealth Park Flying-fox Camp Management Plan*, Proposal to National Capital Authority, Burleigh Heads

Report compiled by Ecosure Pty Ltd

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PR4115-RE.CPFFMP.R1

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