Batemans Bay Flying-fox Camp Assessment

Supplementary Report

May 2016

Eurobodalla Shire Council

ecology / vegetation / wildlife / aquatic ecology / GIS

Acronyms and abbreviations

Council	Eurobodalla Shire Council
EEC	Endangered Ecological Community
GHFF	Grey-headed flying-fox (*Pteropus poliocephalus*)
OEH	NSW Office of Environment and Heritage
the Management Plan	Water Gardens Grey-headed Flying-fox Camp Management Plan (Eco Logical 2015)

Contents

1 Background

Grey-headed flying-foxes (*Pteropus poliocephalus*; GHFF) have been seasonally roosting at the Water Gardens in Batemans Bay for a number of years. The first monitoring record is from November 2012 when the Federally-funded National Flying-fox Monitoring Program commenced.

In 2015 Eurobodalla Shire Council developed the Water Gardens Grey-headed Flying-fox Camp Management Plan (the Management Plan) (Eco Logical Australia 2015), which was adopted by Council in December 2015. Up until February 2015 the highest count was 20,000 (in February 2014), however it is noted in the Management Plan that March and April 2015 were higher again. In March-April 2016 peak seasonal numbers again increased with estimates exceeding 100,000 (pers. comm. J. Bentley, Office of Environment and Heritage {OEH} 29th April 2016). This influx has caused flying-foxes to spill over into several sites within Catalina which are only rarely used during influxes (Appendix 1). In response to the increase in numbers and associated conflict with the local community, Eurobodalla Shire Council engaged Ecosure in April 2016 to:

- reassess the situation at the Water Gardens, Catalina and surrounds
- provide advice on current management options, including dispersal
- identify likely costs, risks and likelihood of success of the suggested management options.

Ecosure assessed the Batemans Bay and Catalina camps on 29th April 2016. The following is a supplement to the Management Plan (Eco Logical 2015) providing results of Ecosure's assessment, and offering potential management options in response to the recent influx.

2 Site assessment

The following is an overview of results from Ecosure's assessment on the 29th April 2016. General habitat assessment, camp extent and consultation were prioritised within the limited site assessment time and as such a count was not undertaken. Estimates are based on ongoing OEH camp monitoring.

2.1 Flying-fox local population

The general GHFF camp extent was consistent with the April 22 distribution mapped by OEH (Appendix 1). There was evidence that the extent has recently contracted around the Water Gardens (at a finer scale than could be shown in the camp extent map) with many individual trees on the outskirts recently used for roosting unoccupied. This is assumed to be a result of more favourable roost space becoming available through a reduction in numbers. There was also a visual reduction in density apparent throughout favoured camp habitat at the Water Gardens (pers. comm. J. Bentley, OEH 29th April 2016).

There are no camps with records of flying-fox occupation[1] within the preferred 20 km foraging vicinity of the Water Gardens and Catalina camps, with the closest two being approximately 23 km north (Kioloa) and 22 km south (Moruya Heads).

2.2 Regional context

Similar large flying-fox influxes have been recorded over the past several months to the south in the Bega area, and north in the Hunter region (pers. comm. M. Roache, OEH April 2016). GHFF camps in the Sydney central region have concurrently reduced (e.g. Wolli camp emptying in April 2016 from over 20,000 in March 2016, pers. comm. W. Jamieson, Avisure Pty Ltd 14 April 2016). Little red flying-foxes (*P. scapulatus*) were also recorded unusually late (i.e. April) in the Hunter Valley area, having generally continued their migration to northern maternity camps by this time. These temporary distribution shifts, which are relatively uncommon at this scale, correlate with bloodwood flowering and exceptional prolific spotted gum flowering around Batemans Bay and to the south combined with above average temperatures.

The primary species of bloodwood and spotted gum in the area are *Corymbia gummifera* and *Corymbia maculata* respectively. Both are considered significant GHFF food trees (Eby and Law 2008).

***Corymbia gummifera* (red bloodwood)**

Corymbia gummifera is a large tree up to 30 m, and occurs on a range of soil types including low fertile sand or sandstone (PlantNET). Flowering predominately occurs from late summer to autumn (Robinson 2003). This species is likely to have been the main attractant to camps

[1] Since the National Flying-fox Monitoring Program commenced in 2012

around Bega to the south of Batemans Bay, which have recently emptied as *C. gummifera* flowering is past its peak. GHFF from these southern camps have likely joined the large number that were already in the Batemans Bay area to take advantage of *Corymbia maculata*, which is still in flower.

***Corymbia maculata* (spotted gum)**

Corymbia maculata grows to 45 m and occurs on a wide range of often shallow, well-drained, clayey soils on valley slopes and ridges; including, infertile and drier sites on shales and slates (PlantNET). Flowering typically occurs from May to Spring (Boland et al. 2006; Clemson1985; Gunn 2001); however, there is evidence to suggest that the species may produce abundant and widespread flowing on a seven-year cycle (Florabank date unknown). If this is the case, such large influxes of flying-foxes in the Batemans Bay area are not expected again for a number of years (potentially around 2023), and should return to the regular seasonal peaks of less than 20,000 supported by annual flowering of *C. gummifera* and other local species.

2.3 Key issues

A comprehensive discussion of community issues associated with the Water Gardens camp is provided in the Management Plan. Issues discussed below are those that have specifically increased since the recent influx of flying-foxes and associated spill over. Please refer to the Management Plan for a more comprehensive list and discussion of issues, including general amenity impacts which would be more widespread with the current overflow camp sites.

2.3.1 Flying-fox electrocution and power outages

The recent influx resulted in numerous local power outages with a higher than normal incidence of flying-foxes being electrocuted on powerlines during evening foraging (pers. comm. Eurobodalla Shire Council, 29th April 2016). This inconvenienced many residents for a number of nights, and created serious health concerns for people relying on medical equipment without back-up power supply.

Power outages were also interfering with mobile phone reception, which was reported as a concern for health and emergency services.

Concerns regarding an increase in dead flying-foxes underneath powerlines have been largely addressed, with the OEH working with the power provider to develop safe carcass handling and removal procedures.

Note that given flying-foxes regularly forage 20 km from their camp (see Section 3.1), and this impact is associated with foraging flying-foxes, dispersal to a camp within 20 km will not resolve this issue.

Recently Essential Energy re-routed power in areas and added separators on some wires, which appears to have largely addressed the issue with no known complaints received in the past two weeks (pers. comm. Eurobodalla Shire Council, 11th May 2016). Telstra also replaced batteries at towers which are expected to resolve issues with mobile phone reception (pers.

comm. Eurobodalla Shire Council, 11th May 2016).

General measures to reduce the incidence of flying-fox electrocution are provided in Section 3.3 should this become an issue again in the future.

2.3.2 Faecal drop

Faecal drop from foraging flying-foxes has inherently increased with the recent influx.

Flying-foxes also have an extremely fast digestive process with only 12 – 30 minutes between eating and excreting (SEQ Catchments 2011). Flying-foxes regularly forage 20 km from their camp (see Section 3.1). Given these factors, dispersing a camp to a new site less than 20 km from its current location will not reduce this impact for the general community as flying-foxes will continue to forage in the local area. As such faecal drop impacts are best managed at an individual property level, as discussed in the Management Plan and in Section 3.4.

2.3.3 Water quality at the Water Gardens

Water quality at the Water Gardens is reported to be poor, and the general condition of the Water Gardens environment is regularly negatively reported by the community. There are a large number of waterfowl that are regularly fed an unnatural diet (bread), which is likely to have a substantial impact on nutrient loading and general water quality, and feeding should be discouraged.

2.3.4 Perception of exponential growth

Each year since 2013 the peak annual number has been higher than the previous year. This has led to community perception that there will be exponential growth if not managed. However, the size of a camp is closely linked with food availability (particularly flowering events) (discussed below in Section 3), and peak numbers are anticipated to reduce again from next year.

2.3.5 Damage to vegetation and exclusion of other fauna

The Water Gardens vegetation is largely Swamp Oak Floodplain, which is an Endangered Ecological Community (EEC). Vegetation damage, particularly to Casuarina spp., has increased due to the influx. However casuarinas generally recover well, and are also fast-growing so if some individuals die as a result of flying-fox damage they will be replaced relatively quickly. Eucalypt species are also generally resilient and most healthy specimens will recover from seasonal roosting in the local area.

There is also some concern that roosting flying-foxes deter other wildlife (e.g. birds and possums). This may be a short-lived effect of large numbers of roosting flying-foxes, however would only be on a very limited scale (i.e. the immediate camp area) and is unlikely to displace fauna from their home territory. Nest boxes in surrounding areas may be considered to provide alternative possum and hollow-nesting bird habitat if displacement is of concern.

Damage to vegetation and possible short-term, fine-scale displacement of some wildlife should also be considered in the broad context of the critical ecological services that flying-foxes provide, which far offset site-specific biodiversity impacts.

3 Management options and considerations

Management options below should be read with referral to those detailed in the Management Plan, which are more comprehensive and detailed than those outlined in this brief supplementary report.

Note that any significant management activity requires a specific plan detailing monitoring requirements and actions to mitigate associated risks (e.g. risks to the community, management personnel, flying-foxes and the environment), and these have not been detailed within this report.

3.1 General considerations

3.1.1 Camp characteristics which affect management outcomes

Impacts associated with flying-foxes foraging during the evening will not be mitigated through dispersal (e.g. power outages, faecal drop, etc.). Flying-foxes regularly travel 20 km from their camp each night to forage, and have been recorded travelling 50 km in a nightly commute (McConkey et al. 2012). Dispersed flying-foxes rarely move far from their original preferred site (generally <600m), and inherently almost always remain within their preferred 20 km radius from the food source that attracted them to the original location in the first instance (Appendix 2).

Flying-foxes also appear to be more frequently roosting and foraging in urban areas. There are many possible drivers for this, 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 droughts
- human disturbance or culling at non-urban camps or orchards
- urban effects on local climate
- refuge from predation
- movement advantages e.g. ease of maneuvering in flight due to the open nature of the habitat or ease of navigation due to landmarks and lighting.

For these reasons, including the fact that flying-foxes will generally prefer to remain within 20 km of the foraging resource that initially attracted them to the area, it is considered highly unlikely that a dispersal will move flying-foxes out of the Batemans Bay urban area.

Given there are no previously occupied camps in the Batemans Bay area, it is almost certain that dispersed flying-foxes would select an alternative within the local urban area. As discussed in Section 3.2, it is not possible to control which site or sites are selected by flying-foxes. Flying-foxes show strong fidelity to their camp sites, and will continuously attempt to re-establish a dispersed camp. Therefore significant habitat modification (see Appendix 3) or ongoing dispersal efforts (e.g. seasonally when flying-foxes are in the local area) would be required to deter attempts to re-establish at the Water Gardens and Catalina camp sites.

3.1.2 Preferred camp characteristics and alternative habitat

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

Optimal vegetation available for flying-foxes must allow movement between preferred areas of the camp. Specifically, it is recommended that the size of a patch be approximately three times the area occupied by flying-foxes at any one time (SEQ Catchments 2012).

There have been no known cases of successfully attracting/relocating GHFF to a site that they have not chosen themselves. The most high profile example is in Melbourne prior to the Melbourne Botanic Gardens camp dispersal, where a committee of experts selected a nearby target location prior to dispersal which was considered suitable flying-fox habitat. Significant effort was spent improving the desired relocation site (Horseshoe Bend) including planting, moving leaf litter from the Botanic Gardens camp, playing recordings of flying-foxes, hanging 200 models of flying-foxes from ropes and erecting a temporary enclosure holding 80 live flying-foxes (GeoLink 2012). Despite these efforts, flying-foxes relocated to at least two unexpected locations (Yarra Bend and Geelong) at a total expense of $3M, and a camp has never established at the desired Horseshoe Bend site. Ongoing funding is required to maintain the Yarra Bend site (DSE 2005).

Regardless of the difficulties in identifying suitable habitat, the provision of suitable alternative locations must be considered as part of long-term management programs where flying-foxes are causing conflict in urban areas. Similarly, all likely potential habitat should be identified prior to dispersal, and the risk of a camp establishing at any or several of these locations thoroughly assessed when evaluating the cost/benefit of a dispersal.

3.2 Managing power outages

Evening power outages can result from foraging flying-foxes being electrocuted. Current work should continue to reduce the number of electrocutions and associated impacts. General measures to reduce flying-fox electrocutions include:

- bundling aerial cables
- increasing spacing between cables
- converting overhead cables underground
- re-routing cables away from high risk areas
- managing foraging resources and restricting access to water sources around high risk areas to reduce localised flying-fox activity
- increasing visibility of powerlines with flagging or similar if low visibility is thought to be contributing to flying-fox electrocution (i.e. collision rather than temporary roosting).

Education should continue to ensure the community is aware of safe protocols for disposing of dead flying-foxes, and the appropriate authority to contact to rescue an injured flying-fox.

Independent of flying-fox activity in the area, advice from equipment retailers and Essential Energy should be sought for any situation where potentially life-support equipment is required. Information from Essential Energy can be found at www.essentialenergy.com.au/content/faqs.

3.3 Property modification

Residents and land managers should consider the following actions on properties adjacent or near to the camp to minimise impacts from roosting and foraging flying-foxes (Note that OEH/Council approval may be required for some activities):

- Create visual/sound/smell barriers with fencing or hedges. To avoid attracting flying-foxes, species selected for hedging should not produce edible fruit or nectar-exuding flowers, should grow in dense formation between two and five metres (Roberts 2006) (or be maintained at less than 5 m). Vegetation that produces fragrant flowers can assist masking camp odour where this is of concern.
- Manage foraging trees (i.e. plants that produce fruit/nectar-exuding flowers, exotic palms) within properties through pruning/covering with bags or wildlife friendly netting (Tolga Bat Hospital 2009) early removal of fruit, or tree replacement.
- Consider fragrant deodorisers where smell is of concern.
- Cover vehicles, structures and clothes lines where faecal contamination is an issue, or remove washing from the line before dawn/dusk.
- Move or cover eating areas (e.g. BBQs and tables) within close proximity to a camp or foraging tree to avoid contamination by flying-foxes.
- Install double-glazed windows, insulation and use air-conditioners when needed to reduce noise disturbance and smell associated with a nearby camp.
- Follow horse husbandry and property management provided at the NSW Department of Primary Industries Hendra virus web page (DPI 2015).
- Include suitable buffers and other provisions (e.g. covered car parks) in planning of new developments.

- Turn off lighting at night which may assist flying-fox navigation and increase fly-over impacts.
- Consider removable covers for swimming pools and ensure working filter and regular chlorine treatment.
- Consider removable covers for boats anchored in Batemans Bay, or other measures to deter flying-foxes landing on masts (e.g. very fine wire, wire coils, randomised laser lighting, etc. could be trailed. Note that flying-foxes will quickly habituate to static deterrents such as predator statues or sound deterrents. Flying-fox hearing range is similar to humans and therefore ultrasonic devices will also have no effect).
- Appropriately manage rain water tanks, including installing first-flush systems.
- Avoid disturbing flying-foxes during the day as this increases camp noise and activity which increases impacts to nearby residents. Methods used to intentionally disturb the camp (e.g. loud noise, smoke, etc.) further impact nearby residents.

The cost would generally be borne by the person or organisation who modifies the property, however as detailed in the Management Plan, Council is providing funding assistance for some services and modifications. Additional subsidies or incentives could be investigated to more effectively manage large influxes of flying-foxes in the local area, and such costs would be lower in the long-term cost with more predictable outcomes than dispersal.

3.4 Tourism opportunities and resident benefit scheme

As discussed in the Management Plan, the Water Gardens could be improved with viewing platforms and other infrastructure so that the camp could be promoted as a tourism opportunity. In addition to associated economic benefits for the local community, a benefit scheme from direct revenue could be investigated as an incentive for nearby residents.

3.5 Education and media opportunities

Education aimed at the community surrounding the Water Gardens has been extensive. This should continue and information should be actively provided to the wider Eurobodalla Council community to mitigate fear around misconceptions, highlight the ecological importance of flying-foxes, provide measures to reduce impacts to the community and encourage community tolerance.

Positive media stories should also be encouraged, for example the effort and resources Council has invested to date and the ecological importance of flying-foxes. The Plan developed for the Water Gardens, including the extensive consultative process, could be promoted as a benchmark to managing community impacts whilst also ensuring flying-foxes and their critical ecological role are conserved.

3.6 Increasing buffers

Buffers can be created through vegetation removal and/or the installation of permanent/semi-permanent deterrents (see Appendix 3).

There is potential to further increase buffers at the Water Gardens camp site. It is recommended that this be done with deterrents that can be 'turned off' during large influxes, to prevent additional spill-over into surrounding areas. Canopy-mounted sprinklers are considered the most appropriate and likely to be successful way to increase buffers for this site. These could be installed at the edges of the camp to encourage flying-foxes to remain towards the centre of the Water Gardens most of the time, and could be turned off for short periods during large influxes. Canopy-mounted sprinklers can be installed for approximately $1,500 per sprinkler.

The Catalina camps have only been historically used to accommodate overflow from the Water Gardens during large influxes, and it is anticipated that flying-fox numbers in these areas will be minimal outside uncommon prolific flowering events. It is likely that flying-foxes will abandon Catalina when spotted gum flowering finishes in the coming weeks. However, if flying-foxes return to undesirable locations in Catalina in the next season, habitat modification through selective tree trimming/removal could be investigated to make buffer areas (e.g. 10-20 m) unattractive to roosting flying-foxes. Sprinklers could also be considered.

3.7 Dispersal

Dispersal aims to move a camp away from an undesirable location. Dispersal may be through disturbance (active dispersal) or habitat modification (passive dispersal). Note that risks discussed in Section 3.8.1 apply to any passive or active dispersal method.

Passive dispersal through habitat modification

Removing vegetation in a staged manner can be used to passively disperse a camp, by gradually making the habitat unattractive so that flying-foxes will disperse of their own accord over time with little stress (rather than being more forcefully moved with noise, smoke, etc.). This is less stressful to flying-foxes, and greatly reduces the risk of splinter colonies forming in other locations (as flying-foxes are more likely to move to other known sites within their camp network when not being forced to move immediately, as in active dispersal).

Generally, a significant proportion of vegetation needs to be removed in order to achieve dispersal of flying-foxes from a camp or to prevent camp re-establishment. For example, flying-foxes abandoned a camp in Bundall, Queensland once 70% of the canopy/mid-storey and 90% of the understorey had been removed (Ecosure 2011). Ongoing maintenance of the site is required to prevent vegetation structure returning to levels favourable for colonisation by flying-foxes. Importantly, at nationally important camps sufficient vegetation must be retained to accommodate the maximum number of flying-foxes recorded at the site.

This option may be preferable in situations where the vegetation is of relatively low ecological and amenity value, and alternative known permanent camps are located nearby with capacity to absorb the additional flying-foxes. While the likelihood of splinter colonies forming is lower than with active dispersal, if they do form following vegetation modification there will no longer be an option to encourage flying-foxes back to the original site. This must be carefully considered before modifying habitat.

Habitat may also be significantly modified so that it is unattractive to roosting flying-foxes. For example removing access to water sources flying-foxes use to drink and/or regulate microclimate, or draining a wetland, as has been suggested for the Water Gardens. Note that in addition to risks associated with a dispersal, draining the Water Gardens would destroy the EEC and other values of the site, and would likely make the site unusable for flying-foxes in the future. Although this may be considered preferable to some members of the community, as detailed in Section 3.8.1 and Appendix 4, should a dispersal be unsuccessful and cause more problems it may be preferable to have flying-foxes return to the Water Gardens. If it is permanently modified, this will not be an option.

Active dispersal through disturbance

Active dispersal is when a team of personnel position underneath a camp site to disturb flying-foxes with noise, lights and smoke as they attempt to return from their nightly foraging (e.g. from approximately 0330).

Active dispersal will be disruptive for nearby residents given the timing and nature of activities, and this needs to be considered during planning and community consultation.

Potential short-term impacts on surrounding residents associated with management activities include:

- sleep disruption between 0400 - 0730 on dispersal days
- stress to noise-phobic pets during dispersal
- irritation associated with smoke used for dispersal (residents should contact Council
- if this is likely to cause health impacts so that suitable planning can prevent ill effect)
- disturbance during vegetation management (possibly in the evening)
- increased flying-fox vocalising during the day.

Some level of impact is likely for residents within 150m of the camp, and possibly up to 300m.

Active dispersal method does not explicitly use habitat modification as a means to disperse the camp, however if dispersal is successful, some level of habitat modification should be considered. This will reduce the likelihood of flying-foxes attempting to re-establish the camp and the need for follow-up dispersal as a result. Ecological and aesthetic values will need to be considered for the site, with options for modifying habitat the same as those detailed for buffers above.

3.7.1 Risks

There is a range of potential risks that are greatly increased with dispersal (compared with in situ management such as buffers and property modification). These include:

- splintering the camp into other locations that are equally or more problematic

- shifting the issue to another area
- increased human health risk by stressing the flying-fox population and potentially increasing disease prevalence within it and/or increasing the risk of contact with injured or orphaned flying-foxes
- impacts to nearby residents associated with ongoing dispersal attempts
- negative public perception and backlash
- increased aircraft strike risk associated with changed flying-fox movement patterns
- impact on animal welfare and flying-fox conservation
- impact on habitat value
- excessive initial and/or ongoing capacity and financial investment
- unsuccessful management requiring multiple attempts, which may exacerbate all of the above.

Successful dispersals generally require either:

1. substantial vegetation removal/modification that is likely to incur significant long-term ecological impacts on the camp area, or
2. sustained noise disturbance at the site and intensive monitoring, with subsequent additional dispersals from splinter camps that are considered unsuitable.

Both of the above dispersal approaches are very costly, require ongoing commitment and maintenance, are often not entirely successful, and rarely result in desirable outcomes for all stakeholders (DECCW 2009; Roberts et al. 2011). Dispersal often leads to flying-fox stress, injuries or fatalities, and may lead to increased human health risk, nuisance issues, or human/flying-fox conflict at other sites. Dispersals are generally unpredictable in nature, making accurate budgeting and forecasting impossible, and outcomes are always uncertain. As such, there is a growing view among land managers that it is best to manage camps where they are, and develop strategies to reduce their impact (DECCW 2009). Summaries of previous dispersals are provided in Appendix 2.

For site-specific reasons discussed above in Section 3, attempts to disperse the Water Gardens camp will almost certainly result in splinter camps forming nearby (within 2 km). There are numerous locations which would be considered much more undesirable than the Water Gardens (e.g. next to schools etc.). Eco Logical and OEH mapped likely alternative habitat based on a preliminary assessment which is included in the Management Plan, and in Appendix 5. Note that, as acknowledged by OEH, this was a preliminary assessment only, and likely alternative sites that flying-foxes will attempt to use would in fact be far more numerous.

As detailed elsewhere in this report, and evidenced in the Maclean dispersal case study (Appendix 4), there is high potential for flying-foxes to splinter to multiple sites, while also continuing to attempt to re-establish the known camp sites at Water Gardens and Catalina. Therefore management (e.g. dispersal) would be required at all undesirable sites concurrently on an ongoing basis, and the number of splinter sites will increase until which time flying-foxes select a site which is considered appropriate. However as also highlighted by the Maclean case study, it may be determined in hindsight that the original site is the most appropriate. For this reason, along with its protected status as an EEC, it is not recommended that any permanent habitat modification at the Water Gardens be considered unless flying-foxes relocate to a suitable alternative.

It should also be highlighted that to have any chance of success and sufficiently manage risk, a dispersal requires a strategic and coordinated approach, led by experienced personnel who can quickly respond to unforeseen circumstances. Uncoordinated dispersal attempts will increase the risks outlined above, and will undermine the likelihood of success. Community efforts to assist with dispersal should only be considered as part of a strategic plan, and be overseen by a person experienced in flying-fox behaviour and ecology.

A dispersal would expose Council and the community to all the above mentioned risks. Even if dispersal is only attempted once the overflow sites at Catalina have emptied, dispersal teams will be required in these areas as flying-foxes will attempt to move to these other secondary preferred locations. A one-off dispersal action would cost at least $250,000, however this is unlikely to have any effect in the medium or long-term and an ongoing program would be at a cost of millions of dollars. If this level of expenditure is not considered appropriate by Council and the community, funds would be better spent elsewhere than a dispersal attempt, such as community subsidies and in-situ management (and in any event will have more predictable and likely successful long-term outcomes).

If dispersal is to be progressed a detailed plan is required to manage risks as much as possible. This includes attempting to predict the most suitable timing based on likely flying-fox numbers, reproductive cycle, local flowering, climatic conditions and other variables. The number of variables which influence the likelihood of dispersal success and level of risk of a dispersal are high, further compounding the difficulty in effectively planning and managing a dispersal program.

3.7.2 Legal considerations

The Water Gardens is a ‘nationally important’ camp for the nationally vulnerable GHFF. A referral to the Commonwealth is recommended in light of the substantial proportion of the national population which has recently been in the area, particularly as the species is most vulnerable to food shortages at this time of year.

There are also several examples where legal action against Councils has been pursued where flying-foxes move to an equally or less desirable location as a result of a dispersal. This could include aircraft operators if flying-foxes move closer to Moruya and impact on strike risk.

3.8 Management option summary

Table 1 provides an overview of management options additional to the Water Gardens Grey-headed Flying-fox Camp Management Plan (Eco Logical 2015) considered in response to the uncharacteristic large 2016 flying-fox influx.

Table 1 Analysis of key management options in addition to the Management Plan from a social, environmental, financial and risk perspective

Management option	Social	Environmental	Financial	Risk	Ongoing maintenance required	Recommended
Managing power outages at power lines/sources	High likelihood of reducing impacts	Positive – reduces GHFF mortality	Low-moderate	No risk associated with management	Low	Yes
Incentive scheme for tourism potential	High potential to encourage community tolerance	Positive – encourages appreciation for flying-foxes and allows flying-foxes to remain in-situ	Low, and offset by potential income	No risk associated with management	Low	Yes
Property modification (including subsidies)	Moderate-high potential to mitigate impacts	Positive – facilitates ability to live with flying-foxes	Low-moderate, but much less than dispersal and likely to be more successful	No risk associated with management	Low	Yes
Increasing buffers at Water Gardens and Catalina	Moderate-high potential to mitigate impacts	Positive – facilitates ability to live with flying-foxes	Moderate	Low	Low-moderate	Yes, if required
Investigating and planting/restoring alternative camp habitat in low conflict areas	Moderate-high - if successful will reduce impacts associated with camp proximity	Positive – reduces conflict and improves general ecological value of the area	Moderate-high depending on site condition	Low, although flying-foxes may not use the site	Low-moderate	Yes
Dispersal through disturbance or habitat modification	Likely to impact on the community with risks of splintering, and disturbance associated with ongoing dispersal	Negative – impacts to flying-foxes, other fauna and EEC if permanent modification considered	Very high (millions of dollars)	Very high	High	No

4 Recommendations

Ecosure is arguably the most experienced flying-fox management consultancy in Australia and has been involved in numerous dispersal programs. In our opinion, this is the highest risk dispersal scenario we have assessed, given:

- the likelihood of splinter sites in equally or less desirable locations,
- potential risk to aircraft safety if flying-foxes move closer to Moruya Airport (e.g. to the Moruya Heads camp)
- limitations in modifying EEC habitat at the Water Gardens and surrounds to prevent long-term ongoing management efforts
- the importance of the area for a large proportion of a threatened species.

As such, we strongly recommend against dispersal. A one-off dispersal is considered highly unlikely to achieve any medium or long-term outcome, and therefore funds required (anticipated $250,000 or more) would be better invested elsewhere if Council and the community are unwilling to invest significant ongoing resources required for a long-term dispersal program (millions of dollars). Further, given such large influxes appear tied to the exceptional *C. maculata* flowering events and evidence suggests such flowering is on a seven-year cycle, it is considered likely that such large influxes will not occur again for some years.

Regular seasonal visitation by flying-foxes should continue to be managed by the Management Plan already developed by Eurobodalla Council for the Water Gardens (Eco Logical 2015). For example, subsidy and incentive programs, community education and consultation, potential for tourism opportunities (and possible benefit schemes) and harnessing positive media opportunities.

The following additional in-situ management options (as outlined in Section 3) may be considered to assist managing impacts associated with the large influx for the remainder of the *C. maculata* flowering season, and in preparation for future temporary influxes:

- Continue working with power and mobile phone carriers as required to minimise flying-fox electrocutions and associated power outages.
- Encourage appropriate private property modification, including subsidies where possible.
- Consider increasing buffers between residents and roosting flying-foxes at the Water Gardens using canopy-mounted sprinklers that can be turned off during large influxes to reduce spill over.
- Provide buffers by modifying habitat through selective tree trimming/removal and/or canopy-mounted sprinklers if flying-foxes return to undesirable locations in Catalina next season.
- Investigate locations that may be planted or restored to provide alternative roost habitat in low conflict areas.

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Appendix 1 GHFF roosting extent April 22 2016 (source: Eurobodalla Shire Council)

Appendix 2 Dispersal results summary

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

3. In all cases, dispersed animals did not abandon the local area[2].
4. In 16 of the 17 cases, dispersals did not reduce the number of flying-foxes in the local area.
5. 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.
6. In all cases, it was not possible to predict where replacement camps would form.
7. 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.
8. Repeat dispersal actions were generally required (all cases except where extensive vegetation removal occurred).
9. 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.).

Ecosure, in collaboration with a Griffith University Industry Affiliates Program student, researched outcomes of management in Queensland between November 2013 and November 2014 (the first year since the current Queensland state flying-fox management framework was adopted on 29th November 2013). An overview of findings[3] is summarised below.

1. There were attempts to disperse 25 separate roosts in Queensland (compared with nine roosts between 1990 and June 2013 analysed in Roberts and Eby (2013)). Compared with the historical average (less than 0.4 roosts/year) the number of roosts dispersed in the year since the Code was introduced has increased by 6,250%.
2. Dispersal methods included fog[4], birdfrite, lights, noise, physical deterrents, smoke, extensive vegetation modification, water (including cannons), paintball guns and helicopters.
3. The most common dispersal methods were extensive vegetation modification alone and extensive vegetation modification combined with other methods.
4. In nine of the 24 roosts dispersed, dispersal actions did not reduce the number of flying-foxes in the LGA.
5. In all cases it was not possible to predict where new roosts would form.

[2] Local area is defined as the area within a 20 km radius of the original site = typical feeding area of a flying-fox.

[3] This was based on responses to questionnaires sent to councils: some did not respond and some omitted responses to some questions

[4] Fog refers to artificial smoke or vapours generated by smoke/fog machines. Many chemical substances used to generate smoke/fog in these machines is considered toxic.

6. When flying-foxes were dispersed, they did not move further than 6 km away.
7. As at November 2014 repeat actions had already been required in 18 cases.
8. Conflict for the council and community was resolved in 60% of cases, but with many councils stating that they feel this resolution is only temporary.
9. The financial costs of all dispersal attempts, regardless of methods used were considerable ranging from $7,500 to more than $400,000 (with costs ongoing).

Appendix 3 Creating buffers

Buffers can be created through vegetation removal and/or the installation of permanent/semi-permanent deterrents.

Creating buffers may also involve planting low-growing or spiky plants between residents or other conflict areas and the flying-fox camp. Such plantings can create a visual buffer between the camp and residences or make areas of the camp inaccessible to humans.

Buffers greater than 300 m are likely to be required to fully mitigate amenity impacts (SEQ Catchments 2012). The usefulness of a buffer to mitigate odour and noise impacts generally declines if the camp is within 50 m of human habitation (SEQ Catchments 2012), however any buffer will assist and should be as wide as the site allows.

Buffers without vegetation removal

Permanent or semi-permanent deterrents can be used to make buffer areas unattractive to flying-foxes for roosting, without the need for vegetation removal. This is often an attractive option where vegetation has high ecological or amenity value.

While many deterrents have been trialled in the past with limited success, there are some options worthy of further investigation:

- Visual deterrents – visual deterrents such as plastic bags, fluoro vests (GeoLink 2012) and balloons (Ecosure 2016, pers. exp.) in roost trees have shown to have localised effects, with flying-foxes deterred from roosting within 1-10 m of the deterrents. The type and placement of visual deterrents would need to be varied regularly to avoid habituation.
- Noise emitters on timers – noise needs to be random, varied and unexpected to avoid flying-foxes habituating. As such these emitters would need to be portable, on varying timers and a diverse array of noises would be required. It is likely to require some level of additional disturbance to maintain its effectiveness, and ways to avoid disturbing flying-foxes from desirable areas would need to be identified. This is also likely to be disruptive to nearby residents.
- Smell deterrents – for example, bagged python excrement hung in trees and shrimp paste applied to branches, has previously had a localised effect (GeoLink 2012). Logistics of supplying and regularly applying such deterrents has been a limited factor and prevented ongoing or widespread use. The smell of certain deterrents may also impact nearby residents, and there is potential for flying-foxes to habituate. The feasibility of using eucalyptus and citronella oil have been investigated (SCC unpublished), however were found to be inappropriate given potential environmental impacts and difficulties and costs associated with regular application (e.g. after rainfall).
- Canopy-mounted water sprinklers – this method has been effective in deterring flying-foxes during dispersals (Ecosure personal experience), and a current trial in

Queensland is showing promise for keeping flying-foxes out of designated buffer zones. This option can be logistically difficult (installation and water sourcing) and may be cost-prohibitive. Design and use of sprinklers need to be considerate of animal welfare and features of the site. For example, misting may increase humidity and exacerbate heat stress events, and overuse may impact other environmental values of the site.

Buffers through vegetation removal

Vegetation removal aims to alter the area of the buffer habitat sufficiently so that it is no longer suitable as a camp. The amount required to be removed varies between sites and camps, ranging from some weed removal to removal of most of the canopy vegetation.

Any vegetation removal should be done using a staged approach, with the aim of removing as little native vegetation as possible. This is of particular importance at sites with other values (e.g. ecological or amenity), and in some instances the removal of any native vegetation will not be appropriate. Thorough site assessment will inform whether vegetation management is suitable (e.g. can impacts to other wildlife and/or the community be avoided?).

Removing vegetation can also increase visibility into the camp and noise issues for neighbouring residents which may create further conflict.

The importance of under- and mid-storey vegetation in the buffer area for flying-foxes during heat stress events also requires consideration.

Appendix 4 Outcomes of dispersal: Maclean as a case study

The outcomes and costs of relocating flying-fox camps: insights from the case of Maclean, Australia

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ABSTRACT

Managing flying-fox camps is an increasing challenge for agencies responsible for managing wildlife and residential communities along the east coast of Australia. Conflict has arisen between humans and flying-foxes when camp sites were established in urban areas or when people have settled close to existing camps. People and government agencies have often attempted to disperse the flying-foxes away from these camps in the hope that they will move to different locations, but the success of these attempts has been poorly documented. This paper examines the consequences of a coordinated, government-sponsored attempt to relocate a flying-fox camp in the township of Maclean, northern NSW. This camp was a maternity site that had been occupied regularly for over 100 years. Between 1999 and 2007, the flying-foxes were repeatedly induced to move by subjecting the camp to continuous loud noise. Here we compile records to show that the total cost of this relocation attempt was at least $400,000 including 640 person-hours of effort. Flying-foxes made 23 attempts in those years to return to the original camp, although the frequency of attempts declined over time. Twelve other sites were used during this time as temporary camps, including seven sites not previously occupied. In 2004, flying-foxes established a new continuously-occupied camp in the Iluka township, 16 km north east of Maclean, which was still in use in 2010 (the time of finalising this paper). Residents near to the Iluka camp were by then intensively lobbying governments to disperse the animals from this new location. The outcome after nearly a decade of dispersal attempts at Maclean was that flying-foxes continued to return periodically to the original site, and there were more camp sites established in the region, over a wider area than previously known from historical records, and the number of affected residents experiencing conflict had increased. This experience raises questions of how, and at what spatial and temporal scales, the success of relocation attempts should be determined.

Key words: *Pteropus*, fruit bat, relocation, wildlife management, human–animal conflict, urban economics.

Introduction

The intentional movement of animals or populations from one location to another has become a popular tool to manage wildlife, both for conservation and to resolve human–animal conflicts (Griffith *et al.* 1989; Wolf *et al.* 1996; Fischer and Lindenmayer 2000). In eastern Australia, the relocation of camps of flying-foxes (*Pteropus* spp.) is regularly proposed by some members of the community, typically in cases where these bats have established colonies close to residential areas or when human development occurs too close to established camp sites (Birt *et al.* 1998; Hall and Richards 2000).

The costs of relocating flying-fox camps can be considerable (West 2002; Thiriet 2005; Roberts 2006; Nelson 2008a) and there is ongoing debate around the long-term success of such projects (Hall 2002; Tidemann 2002; West 2002). However, very little effort has been allocated to monitoring the activities involved in previous relocation attempts, or their costs or outcomes, despite their well-established and increasing use in Australia (Hall 2002; Tidemann 2002; West 2002). This paper examines the consequences of attempts to relocate a flying-fox camp at Maclean in north-east New South Wales (NSW). Based on the results, we discuss the utility of relocation as a management tool to resolve conflict between humans and flying-foxes.

Study region and its flying-foxes

Flying-fox camps in the Lower Clarence region

The Lower Clarence region in north-eastern NSW covers an area of approximately 1,500 km^2. Floodplains in the region have been extensively cleared for cane growing and cattle grazing, however, there are still some small areas of remnant rainforest and other types of native vegetation on the floodplains, and extensive areas of sclerophyll forests in the surrounding region (Figure 1). By the end of the twentieth century the human population of the region was

Pp. 277–287 in *The Biology and Conservation of Australasian Bats*, edited by Bradley Law, Peggy Eby, Daniel Lunney and Lindy Lumsden. Royal Zoological Society of NSW, Mosman, NSW, Australia. 2011.

around 17,500, many of whom lived in settlements along the Clarence River.

Flying-foxes were recorded in the region from 1885 (Tanton 1999; West 2002). The region is in the centre of the geographical range of the Grey-headed Flying-fox *Pteropus poliocephalus*, suggesting longer-term occupation (i.e., much longer than historical records). The first quantitative records of the occupancy and abundance of camps commenced with a census of Grey-headed Flying-foxes undertaken by the Australasian Bat Society in July 1998. Since 1998, there have been regular broad-scale systematic surveys of the usage of camps across the Clarence region (Eby *et al.* 1999; Eby unpublished data; Roberts 2006; Roberts unpublished data).

Until 1994, the Grey-headed Flying-fox was the main occupant of camps in the Lower Clarence region, with sporadic influxes of the Little Red Flying-fox *P. scapulatus* (Eby *et al.* 1999; Tanton 1999; West 2002). By 2009, both Grey-headed and Black *P. alecto* Flying-foxes frequently occurred together in camps. According to historical records (Tanton 1999; West 2002), three camp sites have been repeatedly occupied over time: Maclean Rainforest Reserve (MRR), which is described in detail below; Yaegl Nature Reserve (located 2.8 km north east of MRR), which is occupied during late summer and autumn of most years; and Angourie Road (14.8 km east of MRR), which is also occupied most years, but not continuously (Figure 1). Flying-foxes have also been recorded using many other sites in the region as camps, but such sites appear to have been used temporarily or irregularly (Lunney and Moon 1997; Tanton 1999; B. Roberts pers. obs.). In the Lower Clarence, only two locations have been occupied year round: MRR in the absence of disturbances and, since 2004, a camp in the township of Iluka. These year-round camp sites are located in dense riparian rainforest or mangroves (Tanton 1999; Roberts 2006).

Maclean Flying-fox Camp Relocation

MRR is a small (one hectare) patch of remnant subtropical rainforest located on the southwest periphery of the Maclean township (29.4643°S, 153.2042°E; Figure 2). Flying-foxes regularly roosted in MRR from at least the early 1890s to 1999. The number of flying-foxes using this site has fluctuated considerably over time and according to newspaper reports has occasionally exceeded 100,000 individuals (Tanton 1999; West 2002). Historical records show that since the early 1890s flying-foxes using this camp have been repeatedly disturbed by humans, initially to control numbers, and later in attempts to relocate them, so as to reduce vegetation

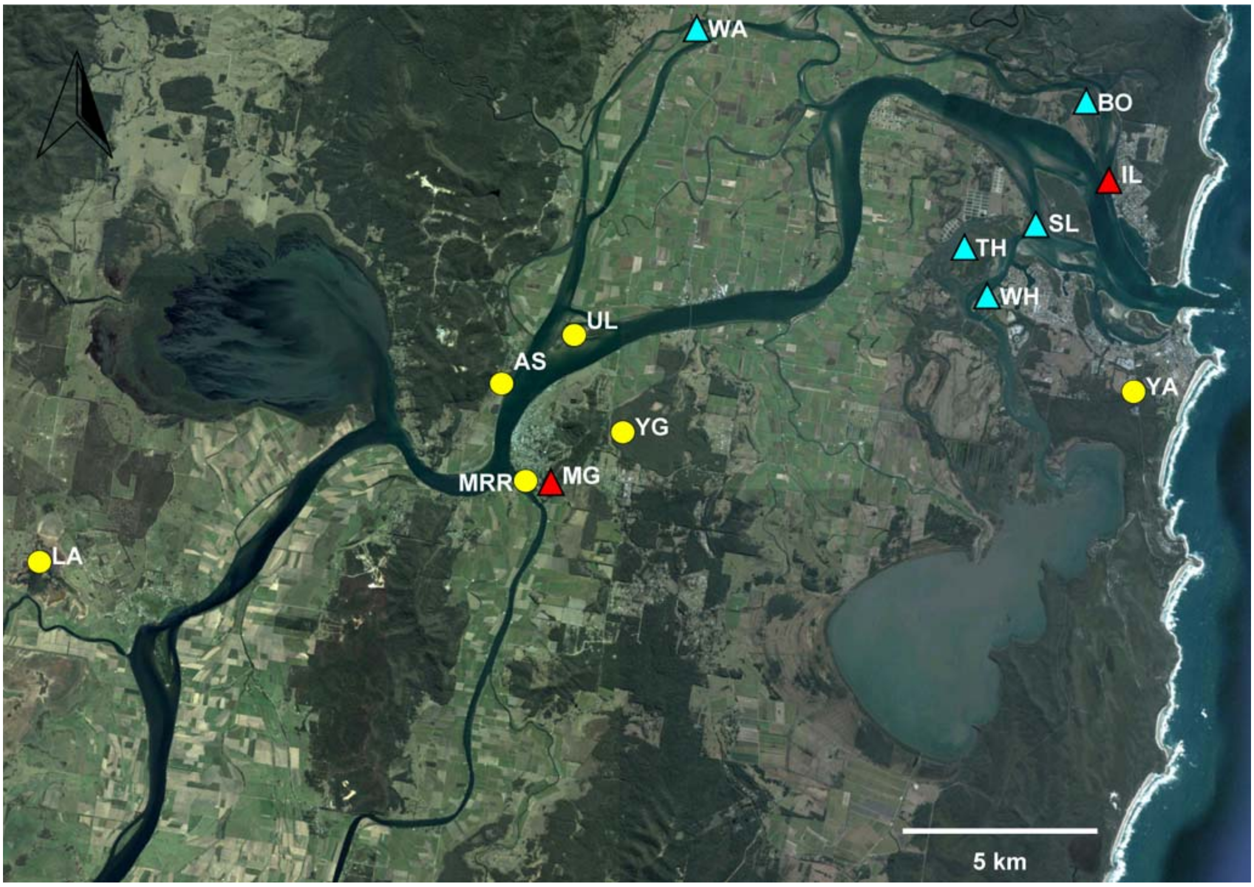

Figure 1: All known flying-fox camps in the Lower Clarence region that were occupied during the period of licensed disturbances (April 1999 to December 2007). Yellow circles = historical sites used prior to the disturbances. Triangles = new sites that were occupied after the disturbance (red triangles continuously occupied sites and blue triangles were temporary sites generally on mangrove islands). AS = Ashby; BO = Bolorobo Island; IL = Iluka; LA = Lawrence (exact location unknown); MG = Maclean gully (350m from MRR); MRR = Maclean Rainforest Reserve; SL = Sleeper Island; TH = Thorny Island; UL = Ulgundahi Island; WA = Warregah Island.; WH = Whyna Island; YA = Yamba; and YG = Yaegl Nature Reserve

damage and impacts upon the neighbouring community (Lunney and Moon 1997; Tanton 1999; West 2002). There are numerous reports of private and government sponsored hunts to destroy or disperse the roosting animals using shooting, fires and explosives (West 2002). However, flying-foxes continued to return to this site despite these disturbances. In the early 1990s, as a result of the legal protection of flying-foxes, these disturbances ceased and animals continuously occupied MRR without further harassment until 1999.

Regardless of the presence of flying-foxes in MRR, the rainforest remnant and the surrounding land were set aside for public use by the Municipal Council of Maclean in 1889 (West 2002). As the Maclean township grew, several community facilities were constructed on the land including a cemetery, showground and, in the early 1960s, the local high school. The initial school buildings were positioned 80 m from MRR, but as the human population of Maclean grew, additional classrooms and other education facilities were constructed closer to the reserve, including construction of classrooms within 10 m of the flying-fox camp in 1996 (West 2002). In 1994 and 1996 there were significant influxes of flying-foxes, primarily Little Red Flying-foxes, into the site (West 2002). This situation prompted increased pressure from the school community and nearby residents for the removal of the bats, due to concerns about the odour, noise, faeces and urine associated with the camp, and the perceived threat of disease transfer from the flying-foxes to the local community (Tanton 1999; West 2002). The roosting flying-foxes also caused damage to parts of the canopy in the small patch of remnant rainforest. Other members of the community, including some residents, conservation groups, and welfare organisations, considered the site important for the local flying-fox population and argued that the camp should be protected. There was public discussion of a variety of management options to reduce the conflict, including relocating either the school or the flying-fox colony. By 1998 the NSW government responded to the ongoing conflict by forming a working party to discuss and implement a draft action plan (West 2002). The working party consisted of representatives from local and state government (including the Department of Education and Training (DET), the National Parks and Wildlife Service (NPWS), and Department of Land and Property Management Authority), the Maclean High School, and other sectors of the community (including the Maclean Parents and Citizens Association). The working party

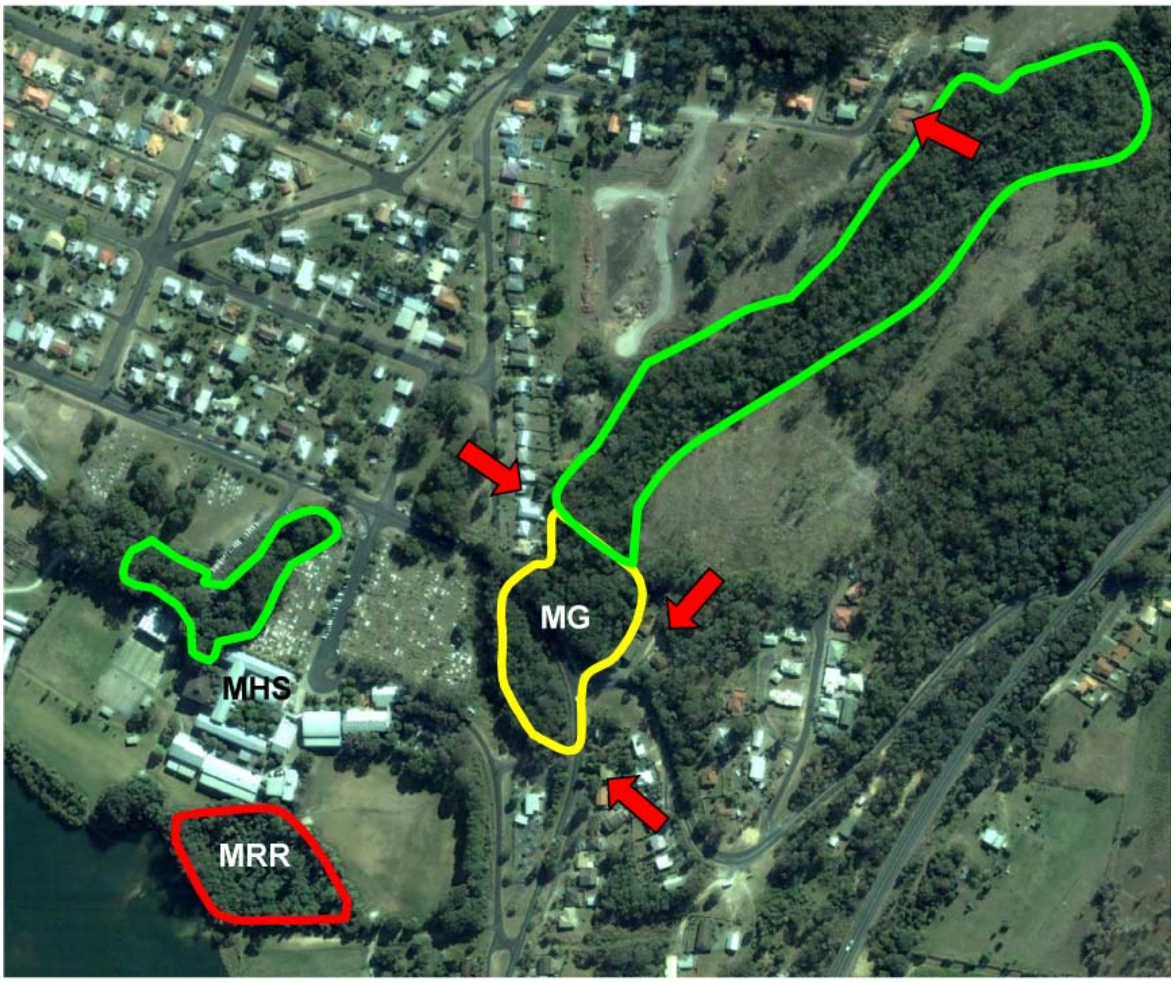

Figure 2: Roost habitat occupied by flying-foxes in the Maclean township. The red outline shows the original site used from at least the early 1890s to 1999 (MRR); the yellow outline shows the lower part of the Maclean gully (MG) occupied continuously since 2007; the green outline shows an additional area occupied at times of maximum population size after 1999 (upper Maclean gully and vegetation adjacent to Maclean High School, MHS). Arrows show residences impacted; further residential development has also been approved for the cleared areas around the Maclean gully.

decided that the flying-fox colony should be subjected to a controlled disturbance regime, which aimed to reduce bat numbers at MRR and to induce them to move to the nearby Yaegl Nature Reserve. Repeated, but irregular, use by flying-foxes (generally between February and June) had previously been reported at Yaegl. The species that frequented the site was generally unknown because of its inaccessibility. Recent observations suggest the Yaegl camp is primarily used by Little Red Flying-foxes, although Black and Grey-headed Flying-foxes are also known to have used the site.

The relocation efforts broadly followed advice from a bat expert (relocation proposal by Dr C. Tidemann included in Tanton 1999). However, this was a controversial decision, and other bat ecologists questioned whether it would be an effective long-term solution (West 2002). The relocation activities at MRR, using loud noise, commenced in 1999 and were repeated in subsequent years, on an as-needs basis. By early 2000, the area of disturbance needed to be expanded to include nearby residential areas (which flying-foxes had by then begun to use). Dispersals ceased after 2007, due to a Federal government requirement for a new environmental assessment after the local Clarence Valley Council became a joint applicant for approvals (with DET). A new application to continue relocation of flying-foxes from Maclean was pending approval at the time of finalising this paper (2010).

Methods

Response of Maclean flying-foxes to relocation: survey methods

Data on flying-fox occupancy and abundance within camps across the Lower Clarence region over the period of April 1999 to December 2007 were compiled from a survey of the literature (Eby *et al.* 1999; Tanton 1999; Tidemann 2002; West 2002; Tidemann 2003; Roberts 2006), and monthly camp site surveys conducted from September 2007 to December 2009 as part of a broader research project (Roberts unpublished data). Information relevant to the relocation of flying-foxes from MRR was obtained from the three involved stakeholders (the NSW Department of Environment, Climate Change and Water (DECCW), DET, and the Clarence Valley Council) through applications made under the NSW Freedom of Information Act 1982 (FOI).

We obtained additional information about the location of historically- and currently-used camps in the Lower Clarence region, patterns of flying-fox occupancy and abundance, and details of the attempts to relocate flying-foxes from MRR from the following sources: field notes of biologists and naturalists (P. Eby, B. Roberts, M. Williams, J. Kennedy); records of interested, long-term residents (G. Bennett, C. West, P. Wrightson); and interviews with council staff (B. Sansom, N. Greenup, M. Forester) and persons living near MRR (J. Storock, J. Clowes, H. Naylor).

Determining financial costs and disturbance effort

Costs associated with the relocation attempts were obtained from involved stakeholders (DECCW, DET and the Clarence Valley Council) through Freedom of Information (FOI) requests to the NSW State government. Costs were allocated to one of several categories including consultant fees and wages, plans of management, logistics of the dispersal, research and acquisition of alternative habitat. Actual costs associated with some aspects of the disturbance were difficult to obtain and it is likely that some components have not been included in the total cost. The effort (person-hours) required to disperse flying-foxes from Maclean was summarised from information obtained under FOI, conversations with council staff (N. Greenup and M. Forester), author's personal observations and published articles (Tidemann 2002, 2003). Effort was calculated on a monthly basis, using the number of days on which dispersal efforts were known to occur, multiplied by the number of people involved and the total disturbance time per day.

Results

Disturbance method

The standard method used to disturb flying-foxes at MRR consisted of 3 or 4 people working around the camp's perimeter to generate loud, continuous noise. At the time of the initial relocation in April 1999, noise was generated for 30 minutes at dawn and dusk (Tidemann 2002, 2003). Subsequent disturbances lasted for up to 2 hours per day (typically split into two periods: morning before 9 am and afternoon after 2 pm). The noise was generated using stock-whips, car horns, metal drums, gongs, starting pistols, firecrackers, whistles and small-unmuffled two-stroke motors such as chain saw and lawn mower engines. These disturbances were observed to cause an immediate response from the flying-foxes, with the majority of the animals taking to the sky, vocalising and circling around the camp site for prolonged periods of time, ranging from 2 – 20 minutes. Typically, all flying-foxes left the MRR after 2 to 14 days of disturbance activity. The human effort required to remove the animals appeared to be positively related to the number of flying-foxes in the camp, and the length of time that flying-foxes had been allowed to persist at the site prior to being disturbed, although the data does not exist to assess this systematically. Numbers of flying-foxes present at the start of each disturbance period varied, but were typically between 1,000 and 20,000.

Disturbance of flying-foxes at the Maclean camp

During the period of licensed disturbances (April 1999 to December 2007) there were 23 separate documented attempts by flying-foxes to re-establish a camp at MRR (Figure 3). For the 12 months after the first disturbance, there were monthly re-occupation attempts by flying-foxes. From 2000 to 2007, attempts by flying-foxes to re-establish the camp commonly occurred in September/October, during the start of the birthing season. In general, when flying-foxes attempted to return to MRR their numbers built up to 1,000–2,000 individuals over a few days. If further disturbances did not commence immediately, their numbers typically continued to increase rapidly.

After each disturbance, flying-foxes roosted in scattered groups in trees within the high school grounds and the immediate surrounds, and made regular attempts to return to MRR either overnight or once the noise had abated. In most cases, a large proportion of the colony had moved 350 m northeast from MRR into vegetation around a nearby electricity substation and extending into residents' backyards (lower parts of the Maclean gully; Figure 2) (West 2002; Tidemann 2003; B. Roberts pers. obs.). Flying-foxes typically remained in this area for several months, although residents often harassed the animals in an attempt to induce them to move on (B. Roberts pers. obs.).

There were no observations of flying-foxes moving from the MRR to the proposed replacement camp site at Yaegl Nature Reserve nor was there any evidence of an immediate increase in the population of Yaegl at the time of any of the relocations.

After 1999, the frequency of attempts by flying-foxes to re-establish a colony at the MRR progressively declined, although flying-foxes still returned to the site ten years after the initial relocation. Between 2007 and 2009, the bats roosted continuously in the Maclean gully despite frequent unauthorised attempts by local residents to move them. The population size was typically 2,000–7,000, and occasionally reached over 20,000, at which times the roost area expanded 550 m further up the Maclean gully, affecting additional residents (Figure 2). By 2009, flying-foxes were roosting in an area substantially larger than the pre-disturbance camp (i.e., MRR only). At maximum population size, flying-foxes roosted in MRR, both the upper and lower parts of the Maclean gully and spill over into areas around the Maclean High School (Figure 2).

Cost of the relocation

Relocation attempts at Maclean cost at least $400,000 between April 1999 and December 2006, including over 640 person-hours of effort (Table 1; Figure 3). The actual total cost of relocations was difficult to obtain due to the lack of records, the time that had elapsed since the initial relocation, and difficulties with estimating the cost of participation by government representatives. Other costs that have not been included in Table 1, but that would have significantly contributed to the total include: the costs of attendance (time, travel and accommodation) for government representatives at several years of community meetings; wages and administration costs for the various government bodies involved in regulating the relocation; the cost of vaccinating (against Lyssavirus) wildlife carers, veterinarians and government staff who monitored the welfare of the animals during the disturbance (a regulatory condition for the relocation attempt); and legal costs incurred when a conservation group (North Coast Environment Council) took the licence holder (DET) to court to prevent disturbances during the maternity season. Works also took place in the late 1990s to reduce the flying-fox impact on Maclean High School (including covered walkways, air-conditioning and double glazing windows). The cost of these was at least $360,000, although this is not a cost of the relocation but rather one of impact mitigation.

Assessment of flying-fox camp sites used since the relocation

After the initial disturbance of the Maclean flying-fox camp in 1999, at least 12 sites were used as campsites by flying-foxes across the Lower Clarence region (Figure 1). Five had been used as camps prior to the 1999 disturbance (Ulgundahi Is., Angourie, Yaegl Nature Reserve, Ashby and Lawrence) and seven appear to be new sites that were only used after the disturbance (Maclean gully, Whyna Is., Sleeper Is., Thorny Is., Bolorobo Is., Iluka, Warregah Is.). Six of these new camp sites (all except the Maclean gully) are situated in small mangrove patches or islands in which tree cover has only recently (last 15 years) developed or re-developed to the extent where it would provide sufficient roost habitat for the establishment of a flying-fox camp (see Roberts 2005 for roost habitat descriptions). Five were temporary camps

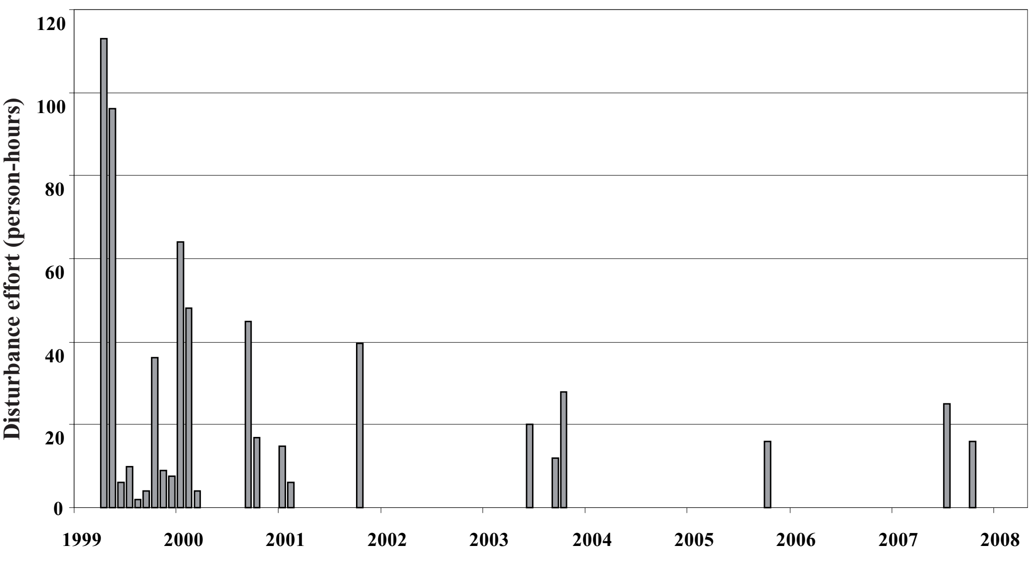

Figure 3 Documented disturbance effort (person-hours) required to disperse flying-foxes from the Maclean Rainforest Reserve during the period of licensed disturbances (April 1999 to December 2007). Note that the data do not include any unauthorised disturbances conducted by residents of Maclean. Data from Tidemann (2003), Clarence Valley Council, and authors.

used by flying-foxes for weeks or months and then abandoned. In 2004, a new camp was established within the Iluka township, 16 km from MRR, and this site was then continuously occupied by flying-foxes until 2010 (when the present paper was finalised). Use of temporary camps in the Lower Clarence largely ceased after the establishment of the Iluka camp. Since the Iluka site is close to residential areas, affected residents subsequently began lobbying governments to disperse the animals from this new location (Roberts 2006).

Discussion

Effect of disturbances on site use by flying-foxes

Has the relocation of the Maclean flying-fox camp been successful? The Maclean example has been termed a success by some researchers (Tidemann 2003, Nelson 2008a, b) and by residents at Maclean and elsewhere who argue in favour of relocating camps. Flying-foxes have indeed failed to maintain a continuous presence in MRR since 1999. However, they have continued with attempts to re-occupy this historically-used camp site (at times for prolonged periods in numbers exceeding 20,000) often prompting conflict with the local school community. Furthermore, flying-foxes are now roosting year-round only 350 m away in the Maclean gully and have also established a new camp in an urban setting 16 km away at Iluka, both of which have resulted in additional conflict with residents. That is, the relocation is unlikely to be considered a success by the broader community or government authorities charged with managing the conflict, who now have to deal with a new set of complaints from Iluka and Maclean residents, while managing the continued attempts by flying-foxes to resume their original Maclean camp. Seen in this light, the Maclean disturbance program, rather than resolving the problem, appears to have merely succeeded in moving the problem elsewhere at considerable and ongoing cost to the local community, and expanding it so that an increasing number of people are affected.

Attempts to relocate flying-fox camps using non-lethal methods have become frequent in recent years (Table 2). Many other relocation attempts have resulted in qualitatively similar outcomes to those observed in the present study of relocation at the Maclean camp. Some have succeeded in moving flying-foxes from their original camp site, however in most cases the effect has been temporary, and ongoing programs of dispersal have been required after the flying-foxes made regular attempts to return, while others have simply been unsuccessful in dispersing the bats (Table 2). Often when disturbances were used to disperse flying-foxes from camps they: initially roosted within 500 m of the site; did not simply join pre-existing camps; did not shift their roosting activities into the "pre-determined" target sites; and did not move to locations acceptable to the broader community (Table 2). More generally, flying-foxes are very mobile animals, and the availability of food resources in the local area is an important influence on patterns of abundance in flying-fox camps (Eby 1991, Parry-Jones and Augee 1992), therefore it is not surprising that disturbance actions have rarely had lasting long-term effects on how flying-foxes use roost habitat.

For example, the dispersal of a camp from the Melbourne Royal Botanical Gardens eventually resulted in flying-foxes establishing two new camps in unexpected locations (Yarra Bend Park and Geelong, 5 and 65 km respectively from Melbourne), rather than at a target site (Horseshoe Bend, 8 km away) identified in the relocation plan (Toop 2004; Department of Sustainability and Environment 2005). Flying-foxes returned almost monthly during the first six months of disturbances at Melbourne, however between 2004 and 2009 flying-foxes made only one

Table 1 Estimated costs of the relocation of flying-foxes from the Maclean Rainforest Reserve and the Melbourne Royal Botanical Gardens. Several additional components of the Maclean costs are not included due to lack of records (see text). Cost for the Melbourne Royal Botanical Gardens derived from S. Toop (pers. comm. 2006) and Department of Sustainability and Environment (2005).

Category	Description	Maclean Rainforest Reserve	Melbourne Royal Botanical Gardens
Consultant fees and wages	Wages for main investigator, assistants and government staff that assisted with the dispersal	$51,000	Between $100,000 and $200,000
Plans of Management	e.g., Maclean, Tanton (1999) and Melbourne, Department of Sustainability and Environment (2005)	$20,000	$1,700,000
Logistics of the Dispersal	Equipment hire or purchase, materials, vehicles, contract labour	$25,000	$250,000
Research projects	e.g., radio-tracking movements, mapping alternative roost sites.	nil	$300,000
Alternative habitat	Cost to purchase alternative habitat (Yaegl Nature Reserve*) and/ or enhance alternative habitat	$300,000	$600,000
		$396,000	**Between $2,950,000 and $3,050,000**

* The Yaegl Nature Reserve was purchased by NPWS in 2001 (with Commonwealth Government assistance) because of reports of increasing use by flying-foxes; and, due to the ecological significance of the dominant Melaleuca swamp forest (a endangered ecological community).

Table 2 Summary of known documented attempts to relocate Australian f lying-fox camps using non-lethal methods, during 1990 to 2009.

Location	Spp*	Population at initial action	Method#	No. of years' disturbance 1990 – 2009	No. of disturbance actions	Dist. (m) moved from initial site	Use of pre-identified site (Distance)	Acceptable new location? (duration of action)	No. of new camps created	Maximum population in 2008–09	Conflict reported during 2008–09?	Source+
Batchelor, NT	B	200	BNS	2	2	<400	none identified	yes (3 months)	1	2,000	no	1,2
Boyne Island, Qld	BR	25,000	LNS	3	3+	<500	temporarily (400 m)	yes (9 months)	unknown but at least 2	nil	at related site	3,4,5
Charters Towers, Qld	BR	40,000	HLNPOW	9	10+	200	none identified	no	unknown	40,000	yes	6,7
Dallis Park, NSW	BG	28,000	V	2	2	300	none identified	no	2	nil	at related site	8,9
Maclean, NSW	BGR	20,000	NS	6	23	350	no (3 km)	no	7	>20,000	yes	10
Mataranka, NT	BR	>200,000	BHLNOSW	10	9+	<300	none identified	no	unknown	>200,000	yes	11,12,13
Royal Botanic Gardens, Melbourne, Vic	G	30,000	NS	4	7	<500	no (8 km)	yes (6 months)	2	nil	no	14,15,16
Royal Botanic Gardens, Sydney, NSW	G	3,000	LNPOW	7	10	<900	none identified	no	0	20,000	yes	11,16,17
Singleton, NSW	GR	500	LNUW	2	3	max 900	none identified	no	0	14,000	yes	3,16,18, 19
Townsville, Qld	BR	35,000	BNS	3	2–5	400	none identified	no	unknown	20,000	yes	6, 20

* G = Grey-headed Flying-fox; B = Black Flying-fox; R = Little Red Flying-fox
\# B = "birdfrite"; H = helicopter; L = lights; N = noise; P = physical deterrent; O = odour; S = smoke; U = ultrasonic sound; V = vegetation destruction; W = water.
\+ 1 Phillips *et al.* 2007, 2 J. McCarthy (Northern Territory Government, pers comm. 2010), 3 Roberts 2006, 4 Queensland Parks and Wildlife Service 2002, 5 J. Adair (Department of Environment and Resource Management, pers. comm. 2010), 6 S. Sullivan (Department of Environment and Resource Management, pers. comm. 2010), 7 Charters Towers Regional Council (pers. comm. 2010), 8 Welbergen 2005, 9 Roberts 2008, 10 This study, 11 Vardon *et al.* 1997, 12 Carol Palmer (Northern Territory Government, pers. comm. 2010), 13 Eddie Webber (Northern Territory Government, pers. comm. 2010), 14 Tanton 1999, 15 Toop 2004, 16 van der Ree and North 2009, 17 Richards 2002, 18 Singleton City Council 2008, 19 Stevenson 2004, 20 Billabong Sanctuary (pers. comm. 2010).

attempt to return (R. van der Ree pers. comm. 2010). There have been three separate attempts to move roosting flying-foxes from a public park in Singleton (NSW) using spotlights and reflective material, water from fire hoses and sprinkler systems, and loud noise, with no success (Roberts 2006; Fletcher 2010). At Dallis Park (Murwillumbah, NSW) the habitat of a roost site was destroyed in 2004 to disperse and prevent re-establishment attempts by flying-foxes. The Murwillumbah area has been extensively cleared for agriculture and the flying-foxes utilised the nearest available patch of dense tall forest. Once the vegetation at Dallis Park had regrown to a suitable height three years later, the flying-foxes attempted to re-establish the original camp (Roberts 2008).

At present, knowledge of the movement patterns of flying-foxes and the factors influencing the establishment and persistence of their camps is insufficient to accurately predict where flying-foxes will move once relocated from a particular camp. For example, prior to disturbances of the Grey-headed and Black Flying-foxes that roosted at MRR, it was suggested that they could be shifted to nearby Yaegl Nature Reserve (Tanton 1999; Tidemann 2002, 2003). However, this did not occur. Instead, Yaegl has been primarily used for short periods of time during late summer and autumn by nomadic groups of Little Red Flying-foxes.

Relocations also have the potential to shift flying-fox camps to nearby, possibly more controversial sites. In eastern Australia, flying-fox camps occur in a variety of habitats from continuous forest to small remnant forest patches (Eby 2002; Roberts 2005), but there is emerging evidence that there is a tendency for camps to be situated in urban environments (Birt *et al.* 1998; Hall 2002; Roberts 2005). Therefore, further relocation attempts in Maclean or Iluka may result in a shift to other urban areas in the region.

Cost-effectiveness of relocation attempts

An additional factor that requires consideration when assessing the success of a relocation attempt is the cost of dispersal. Cost is relevant because in most situations there may be a range of alternative management actions to reduce conflict other than dispersal, such as subsidising double-glazing of windows and the air-conditioning of rooms to reduce impacts of noise and smell (see Roberts 2006). In some situations it may be possible to manage camp vegetation to encourage flying-foxes to roost further from areas of human activity (Coffs Harbour City Council 2007). Unlike dispersal, these mitigation measures have a relatively certain outcome. The issues of alternative approaches to the problem, their costs, and their social acceptability can be very complex. However, to date neither the alternatives to dispersal nor the long-term activities required for relocation have been fully costed, either at Maclean or elsewhere.

The present paper is the first time where some attempt has been made to quantify the long-term cost of dispersing flying-foxes from their roost sites. The cost of relocating flying-foxes from Maclean so far has exceeded $400,000 by an unknown quantity (and still counting, as efforts are planned to continue) (Table 1). By comparison, Singleton City Council has spent approximately $117,000 on attempts to relocate flying-foxes from Burdekin Park, and estimated that another $320,000 over a three-year period would be needed (A. Fletcher pers. comm. 2006; Fletcher 2010). In Melbourne, thousands of person-hours of effort and approximately $3 million were needed (including associated research and purchase of additional habitat) (Table 1). The benefits of the Melbourne relocation in reducing conflict with the general community and protecting heritage trees could perhaps be considered to outweigh the financial cost. However, these resources are beyond the means of most small rural and regional communities.

Managing flying-fox relocations in the future

Relocation continues to be viewed as an attractive solution to problems arising from flying-fox camps in urban areas. For example, between 2006 and 2009, proposals were made to State and/ or Commonwealth government to relocate eight flying-fox camps in NSW, Queensland and the Northern Territory. However, it is important to determine the magnitude of the perceived problem before exploring potential management options, including relocation. For example, if noise, smell and faeces from a camp affect only a small number of residents, then more local-scale mitigation options such as creating buffers between houses and roosting flying-foxes or constructing sound barriers may be more effective solutions than attempted wholesale relocation of a camp (see Roberts 2006 for review of further management options and their estimated costs).

In many cases, public education campaigns can reduce antipathy towards flying-foxes and reduce the social or political imperative to 'do something' about flying-fox camps. For example, managers of some urban camps (e.g., Bellingen, Coffs Harbour, Wingham Brush and Ku-ring-gai (Gordon) in NSW, and Woodend in Ipswich, Queensland), have acted to alleviate the concerns of nearby residents through strategies such as community-based camp revegetation programs, coupled with minor habitat modification around the camp's periphery, education days, and the promotion of tourism to camp sites (Pallin 2000; Smith 2002; Coffs Harbour City Council 2007; Hall 2006). Similar approaches have been used to successfully manage residents' concerns around six flying-fox camps in suburban Brisbane, Queensland, that were considered potential sources of major conflict (Hall 2002, 2006).

Many of the conflicts between humans and flying-fox camps may be attributed to poor planning and inappropriate development near established camp sites (West 2002; Smith 2002; Eby 2002). Creating public open space buffers around established camp sites, aligned with more sympathetic developments, could minimise future conflict, particularly in new residential areas. This is mainly an issue for local government, although there may also be a role for State and/ or Commonwealth planning policies to guide development of areas adjoining flying-fox habitat, given that some flying-foxes species are classified as 'vulnerable to extinction' under State and/ or Commonwealth legislation.

In cases where relocation is considered a preferred management option, the objectives of relocation and of what might constitute 'success' need to be more clearly defined. In particular, the extent of responsibility of the proponent undertaking the relocation to the broader community (e.g., ensuring that any replacement camp is not a source of conflict) needs to be explicitly identified. The length of commitment to relocation also needs to be clearly understood by proponents, given that flying-foxes show high fidelity to traditionally-used camp sites (Ratcliffe 1931; Nelson 1965; Eby 1995; Richards 1995; Tidemann 1999; Tidemann *et al.* 1999). The continued attempts by flying-foxes to re-establish the Maclean camp may be related to the role of the site as a maternity camp. As flying-foxes can live for over 15 years in the wild (Martin and McIlwee 2002; Divljan *et al.* 2006), attempts to re-establish the MRR camp may continue for another few years (if sites are occupied on the basis of individual memory), or indefinitely (if sites are occupied on the basis of habitat attributes or cultural transmission). Such factors need to be considered and addressed in decisions to disperse or relocate flying-fox camps.

Future relocation attempts also need to be accompanied by an adequate monitoring program, to record the actions taken and their costs, and also to determine the short- and long-term outcomes of the disturbance. Monitoring of the outcomes could include both tracking the individual movements of affected animals (for example, with satellite- or radio-telemetry) over the first 12 months, and regularly monitoring of both the original site (i.e., species present, their abundance, breeding status) and other sites in the region. Without such monitoring, there is a significant risk that attempts at relocation will continue to be represented by proponents as 'successful', when in fact they have simply shifted the problem to other places or to the future, rather than solved it.

Conclusion

The resolution of conflicts between humans and flying-foxes is important to the conservation and management of flying-foxes in Australia. The use of disturbance to induce camp relocation is currently commonly proposed as a management tool to reduce conflicts between humans and flying-foxes. However, such relocation attempts have largely been carried out in an *ad hoc* fashion and have lacked systematic documentation, costing and monitoring. Further, most relocations have had limited success in moving the flying-foxes to new sites, in some cases these new sites have been in unanticipated and undesirable locations, and relocation attempts may be costly. The location of flying-fox camps in urban areas is likely to continue to be an issue of community conflict and conservation concern in the future. A better understanding of flying-fox relocations will significantly assist organisations responsible for managing flying-fox camps and help identify long-term management solutions that are both ecologically-sound and acceptable to the entire community.

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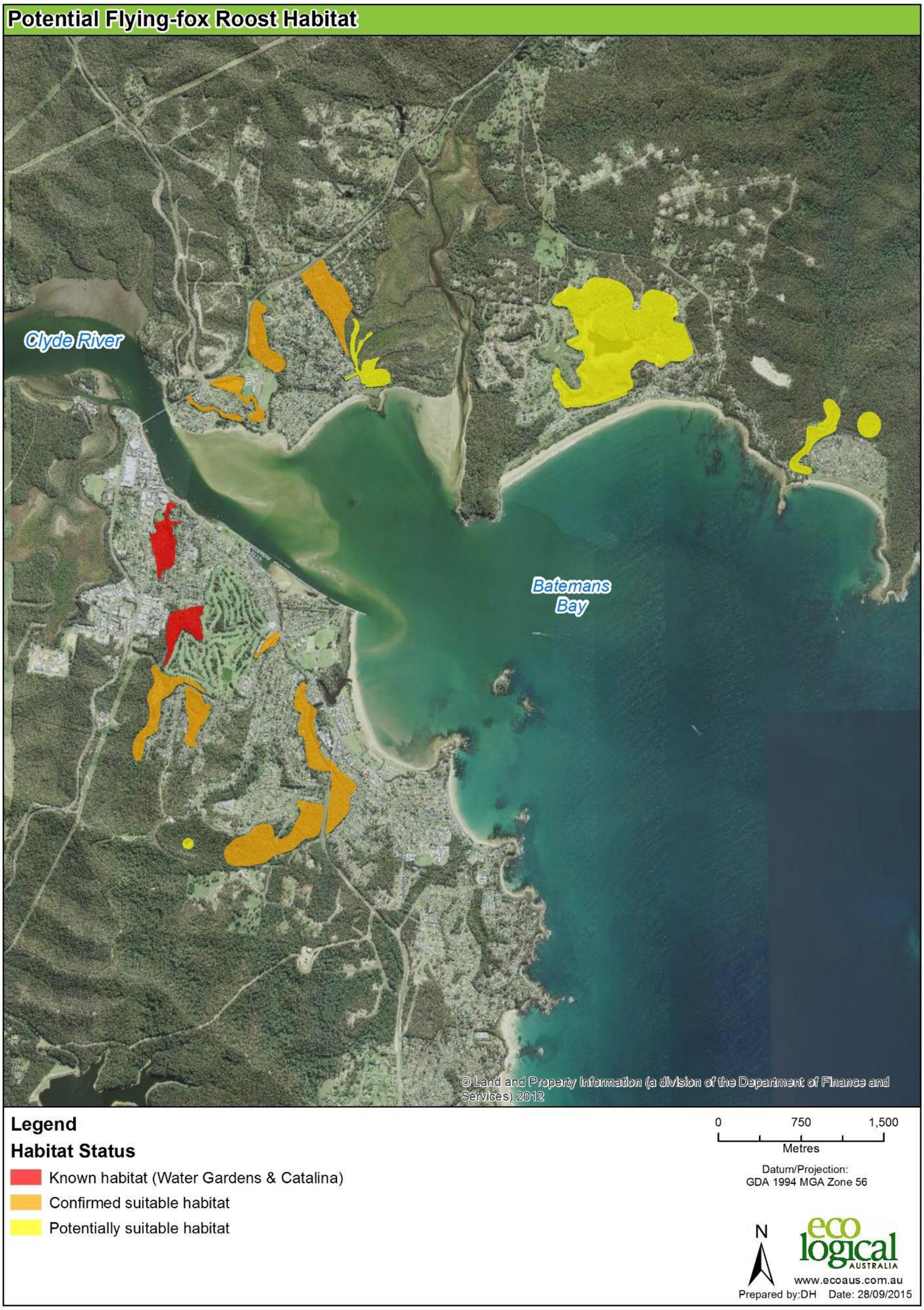
Appendix 5 Potential habitat map (source Eco Logical 2015)



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01	11/05/2016	Batemans Bay Supplementary Report - DRAFT		Jess Bracks, Principal Wildlife Biologist (incorporating client comments)	
02	12/05/2016	Batemans Bay Supplementary Report - Final		Jess Bracks, Principal Wildlife Biologist (incorporating client comments)	
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