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

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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

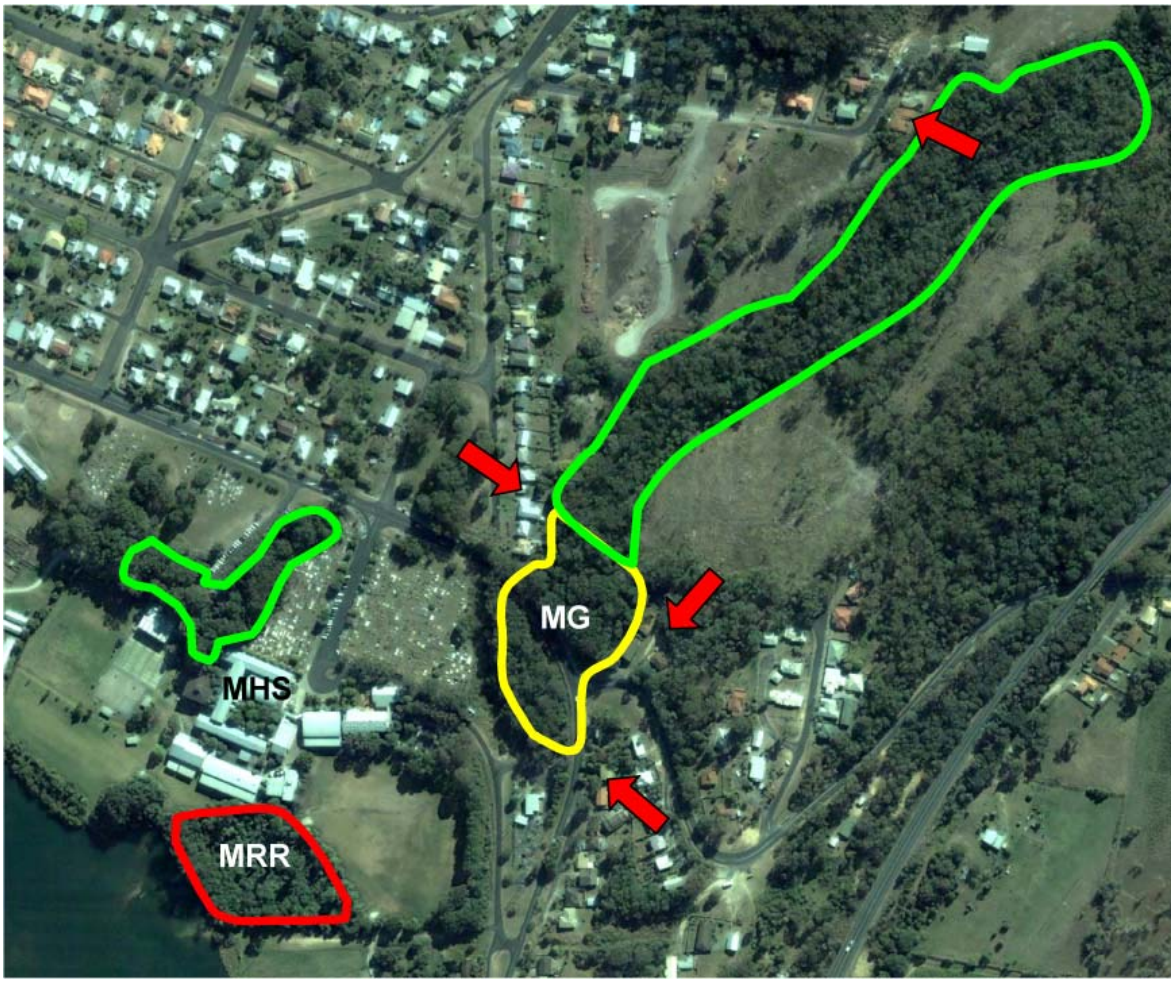

Figure 2: Roost habitat occupied by flying-foxes in the Maclean township. The red outline shows the original site used from at least the early 1890s to 1999 (MRR); the yellow outline shows the lower part of the Maclean gully (MG) occupied continuously since 2007; the green outline shows an additional 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

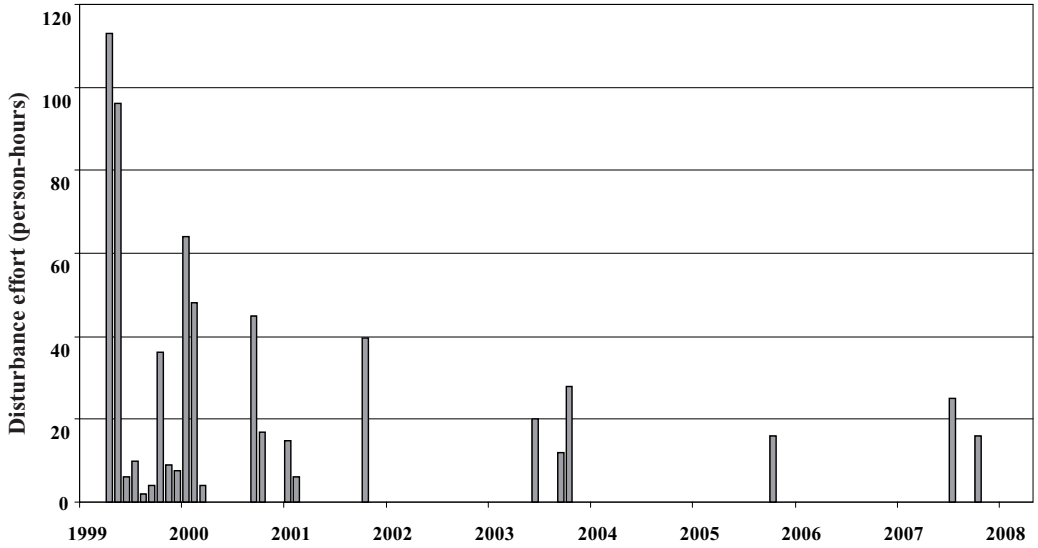

Figure 3 Documented disturbance effort (person-hours) required to disperse flying-foxes from the Maclean Rainforest Reserve during the period of licensed disturbances (April 1999 to December 2007). Note that the data do not include any unauthorised disturbances conducted by residents of Maclean. Data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