Ku-ring-gai Flying-fox Reserve

Habitat restoration project, 15 years on

By Nancy Pallin

Strong community support led to government protection of a bat colony in northern Sydney in 1985. Restoration of the roosting habitat of the Grey-headed Flying-fox (Pteropus poliocephalus) was implemented by a non-government organization in cooperation with the local government. The aims, methods, results and challenges of the project so far are outlined.

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A colony of Grey-headed Flying-foxes (*Pteropus poliocephalus*) roosts in urban bushland in the northern Sydney suburb of Gordon (13.5 km north of the central business district). Environment groups became aware of its location following a survey of bushland in the Ku-ring-gai Local Government Area (Buchanan 1983). Part of the land occupied by the flying-foxes was privately owned and a proposal to develop this for housing led to strong lobbying by the community for protection of the bat colony. The NSW Government and Ku-ring-gai Municipal Council jointly purchased the private land in 1985. This land was amalgamated with Council-owned bushland and named Ku-ring-gai Flying-fox Reserve (14.6 ha) in 1991.

The Ku-ring-gai Bat Colony Committee, now the Ku-ring-gai Bat Conservation Society Inc. (KBCS), formed in 1985, recognized a longer term threat to the flying-fox colony. Serious die-back of the canopy trees used by the roosting flying-foxes was occurring and severe weed infestation of the understorey was preventing regeneration of new trees. A site assessment commissioned by KBCS stated: 'The native vegetation is dying and will be replaced within the next 15–30 years by a tall shrub layer consisting of Lantana (*Lantana camara*), Small-leaved Privet (*Ligustrum sinense*), Large-leaved Privet (*Ligustrum lucidum*) and one native species, Pittosporum (*Pittosporum undulatum*). Morning Glory (*Ipomoea indica*) and 'Trad' (Wandering Jew; *Trad fluminensis*) will also remain very common. The trees, Blackbutt (*Eucalyptus pilularis*), Turpentine (*Syncarpia glomulifera*), Sydney Red Gum (*Angophora costata*) and Red Mahogany (*Eucalyptus resinifera*) will no longer be present (Buchanan 1985)'.

Loss of this habitat could result in flying-foxes moving to an unknown, next-best site in the Sydney area with the potential for conflict between people and bats. As it takes decades for trees to grow to a size capable of withstanding flying-foxes roosting in their canopy, immediate intervention appeared to be the best course of action.

Flying-foxes at Gordon

Flying-foxes were seen to rise out of the valley east of Gordon in the 1940s (H. George, pers. comm., 1983). From 1963, the gardener of a neighbouring property, Lady Gowrie Nursing Home, noticed flying-foxes camped each summer along Stoney Creek and on the steep, north-facing slope in what is now the western section of the Reserve. Breeding was observed and the colony numbered approximately 2000 in 1973 (Robinson 1973). The colony occupied between 1 and 2 ha and began occupying the site throughout the year (Puddicombe 1981). Regular counts during the nightly exodus from the valley, from March 1985 to June 1990, fluctuated from a few hundred to one peak of 80 000 in February 1987 (Parry-Jones 1993). Counts between December 1994 and November 1997 again showed fluctuations between zero and 59 000 (D. Ford & M. Augee, pers. comm., 1998). Monthly counts from July 1998 to June 1999 recorded a winter population of 13 000, rising to 45 000 in summer (M. Beck, pers. comm., 1999).

The colony has occupied an area of 2–3 ha, with variations according to fluctuations in the numbers in residence at any particular time. Since the early 1980s there has been a gradual shift eastward of the colony from the western end of the Reserve to the present position in the central section (Fig. 1), and it appears that the flying-foxes prefer to camp on slopes with a northerly aspect, especially in winter. Information gathered by KBCS on other flying-fox colonies at Wingham Brush, Bellingen

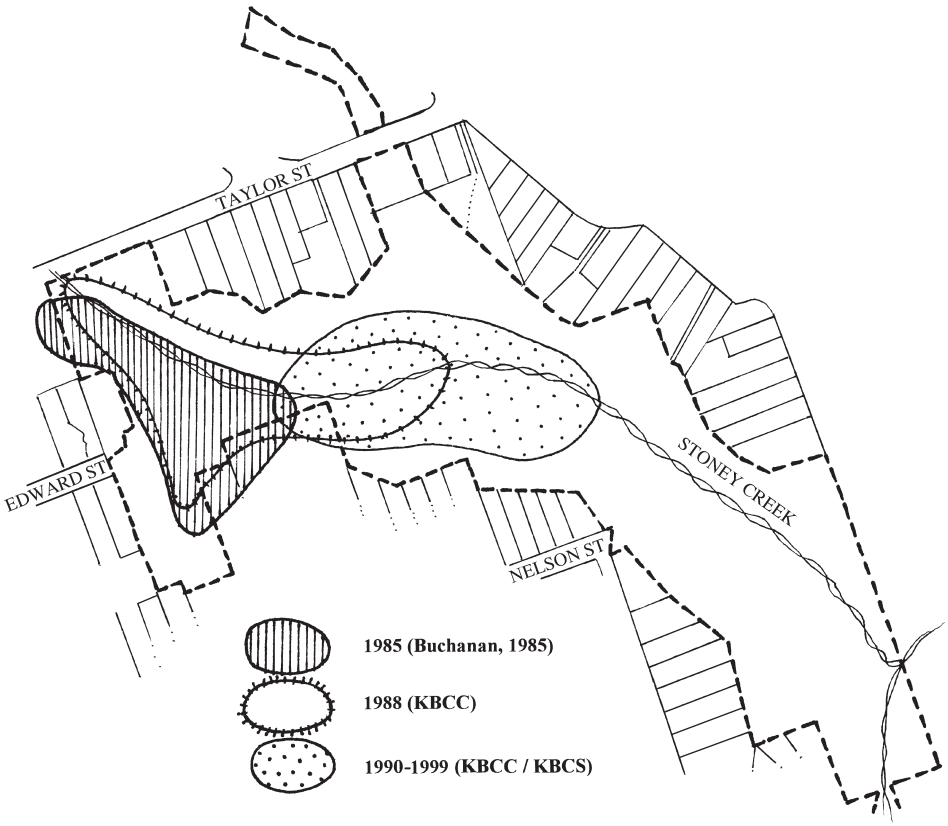

Figure 1. Three 'snapshots' showing the progressive movement of the flying-fox colony over time. Records are available from 1972.

Island, Susan Island, Maclean, Booyong, Jamberoo and Indooroopilly Island confirmed that they occupy different parts of the available habitat over time. While the reasons for such shifts are not known, such movements would allow recovery of the tree canopy, given that defoliation of branches occurs at regularly used roosts.

Flying-fox colonies occur in many different vegetation types including rainforest, casuarinas, mangroves and in native and exotic trees in the Botanic Gardens in Sydney and Melbourne. This would suggest that the structure of the vegetation is more important than species of tree. The Gordon bat colony site assessment identified that flying-foxes use vegetation consisting of four layers (Buchanan 1985). They used the tallest trees, Blackbutts and angophoras, to warm themselves on cool early mornings and to cool themselves in summer breezes. The most commonly used layer was the (somewhat lower) Turpentine canopy, with taller shrubs used in high temperatures or on cold, windy days. In extreme heat (greater than 40°C) with dry westerly winds, a local resident had observed bats on the ground and clinging to rock faces where seepages occurred.

Aims of the project

The primary aim of the habitat restoration project was to provide self-perpetuating indigenous roosting habitat for the colony of Grey-headed Flying-foxes. A secondary aim was to retain the diversity of native fauna and flora within the Reserve. A further issue was that the regenerated vegetation should be compatible with native bushland in northern Sydney.

Habitat restoration start

Habitat restoration work focused on bushland weed control, initially undertaken by a small group of volunteers. Four hours per week, four to 10 'friends of bats', some experienced in techniques of bush regeneration practised in other parts of Sydney, girded their loins with the uniform tool pouch, loppers and herbicide bottle (glyphosate). They began the seemingly impossible task of implementing a weed control strategy based on releasing all areas with natural regeneration capacity from suppression by weed (Buchanan 1985; Wright 1991).

Phase 1: 1987–90

The work of the volunteer team was later supplemented by a contract team, whose employment was made possible by a series of grants gained by the KBCS from the NSW Department of Environment and Planning. These grants were matched dollar for dollar by the Ku-ring-gai Municipal Council. The contract team worked in separate areas from the volunteers using the same techniques (Buchanan 1990). In the first year, a three-person contract team worked 5 days per week for 3 months to undertake additional weed control works on steeper slopes. Subsequently, this work was extended over the year, by contractors working 1 day per week for approximately 40 weeks. This enabled time for regeneration to occur and follow-up weeding to be carried out regularly over all areas.

Phase 2: 1992–97

By 1990, the flying-fox camp had moved eastwards in the valley. This, and a NSW Restoration and Rehabilitation Trust Grant, allowed the contract team to undertake restoration of the very degraded western section that was previously inhabited by the bats.

Phase 3: 1998–2000

A Natural Heritage Trust (Commonwealth Government) grant enabled contract bush regenerators to be employed to establish canopy seedlings in a 0.25-ha area within the colony site. This area had only a few Turpentines and Blackbutts left for roosting. Regenerators were also able to prevent further degradation of moderately weed-infested bushland on the northern and southern upper slopes by comprehensive weed control undertaken outside the colony area.

A mosaic of treatments

The reserve contains a mosaic of habitats ranging from rainforest in the riparian zones and lower slopes and sclerophyll habitats on upper slopes. This means that a range of

Grey-headed Flying-fox (*Pteropus poliocephalus*) and Ku-ring-gai Flying-fox Reserve

A Grey-headed Flying-fox licking nectar and pollen from a Turpentine flower (photo: D. Williams).

In 1984, NSW National Parks and Wildlife Service (NPWS) identified the bat colony as 'the largest and most important maternity colony of the Grey-headed fruit bat known in the southern half of New South Wales. As such, it is probably crucial to the future survival of this species in the southern half of the State (McWilliam 1984)'. Since then, radio-telemetry research on the Grey-headed Flying-fox has provided new perspectives on the nomadic foraging behaviour of the species. Colony sites, such as the one at Gordon, are viewed as essential links in a chain of sites which are used permanently, annually or occasionally according to the availability of food resources (Eby 1995). These social mammals roost in trees by day. Colonies vary considerably in size from hundreds to many thousands, fluctuating according to variations in food resources (Parry-Jones & Augee 1991; Tidemann 1995; Eby 1996; Stockard 1996).

Their diet in Australia contains more than 100 species of native trees found in subtropical rainforests, eucalypt forests and woodlands, melaleuca swamps and banksia heaths (Parry-Jones & Augee 1991; Eby 1996). They undertake nomadic movements of hundreds of kilometres in response to unpredictable mass-flowering events in sclerophyll forests (Eby 1991b, 1995, 1996). Large populations of flying-foxes are considered essential to the ongoing ecological functions of seed dispersal and pollination in both rainforest and sclerophyll forests (Eby 1996). They are known to disperse the seeds of at least 40 Australian rainforest trees (including figs, palms and lilly pillies) and are pollen vectors for more than 50 species in the Myrtaceae and Proteaceae (Parry-Jones & Augee 1991; Eby 1995).

Females give birth, annually, to one young in October–November. The infant is carried ventrally by the mother on her nocturnal foraging flights in the first weeks until it can regulate its body temperature. It is then left at the roost overnight, the mother returning by dawn to nurse it during the day until the young learns to fly and feed independently, at approximately 3 months of age. Conception occurs from March to May. Flying-foxes use scent from glands on their shoulders to attract mates and identify young. Females call to their young as they fly into the colony before dawn in early summer. They communicate by using more than 20 different calls (Tidemann 1995).

In the Action Plan for Australian Bats (Duncan *et al*. 1999), Grey-headed Flying-foxes are listed as 'vulnerable' under International Union for the Conservation of Nature and Natural Resources (IUCN) criterion A2 because of a predicted 20% reduction in population within the next 10 years, primarily due to habitat loss.

different management interventions is needed to correspond with the vegetation mosaic. In all areas, however, weed was a common and primary problem. Restoration work which focused on weed control began on the mid-slope near the Edward Street access and progressively worked towards the watercourses and up to the private property boundaries in a patchwork manner (Fig. 2).

Bushland weed control treatments were systematic, with detailed manual removal or precision herbicide spraying of seedlings and herbaceous weeds and 'cut and paint' or stem injection herbicide treatments for larger woody weeds and climbers. These techniques conformed to those documented in Wright (1991) and in the project reports listed in Appendix I and are increasingly used by volunteers and contract bush regenerators in Sydney bushland and beyond. All exotic species were removed from each area rather than working on a species-by-species basis.

Innovative tactics were developed as work progressed. In some areas, for instance, privets were injected with herbicide up to 1 year before the herbaceous weed was to be removed. This prevented a new crop of privet seed forming while most of the previous crop rotted among the herbaceous weed. In other areas (phase 1 sites), work was carried out in a patchwork, initially leaving barriers of weed until a native understorey regenerated. Small areas (30×20 m) with high edge-to-area ratios and surrounded by Trad and vines were found, however, to be costly to maintain, so these weed barriers were gradually eliminated. On steeply sloping sites, the weed infestation was cleared in contour strips to prevent erosion and to maintain habitat for other fauna. Weeds along the private property boundary on the uphill side were retained until native vegetation was established on the mid-slope to prevent wind- and water-borne weed propagules from establishing in the restoration area. Similarly, the creek banks were treated in short sections to minimize erosion.

Trad was raked into rolls (1.5×10 m) along the contour. Periodic herbicide spraying and further rolling, ends-to-middle, promoted composting of this succulent weed. This method successfully disposed of vast quantities of herbaceous weed, a far cheaper and more environmentally friendly option than carting it to landfill. Both regular turning of composting weeds and wrapping weeds in heavy-duty black plastic for more than 18 months was effective in killing grass seeds and Trad stems.

Exotic vines that enveloped the canopy of existing trees: Madeira Vine (*Anredera cordifolia*), Morning Glory (*Ipomoea indica* and *I. purpurea*), Balloon Vine (*Cardiospermum grandiflorum*) and Honeysuckle (*Lonicera japonica*); were removed within phase 1 and 2 areas and (beginning in 1994) were removed along Stoney Creek in an easterly direction (Fig. 2). A concerted effort was made annually to apply herbicide by the stem-scrape method, to kill vines in situ and (particularly in the case of Madeira Vine) to kill existing aerial tubers and prevent the development of more. Madeira Vine tubers were picked from the soil once native seedlings began to regenerate and removed to landfill. Madeira Vine regrowth was spot sprayed with herbicide where there were no native seedlings. Although floods bring more Madeira Vine tubers from upstream sources into the Reserve, this strategy has almost eliminated the production of tubers within the Reserve and thus protects the regenerating areas and bushland downstream in Garigal National Park from this threat.

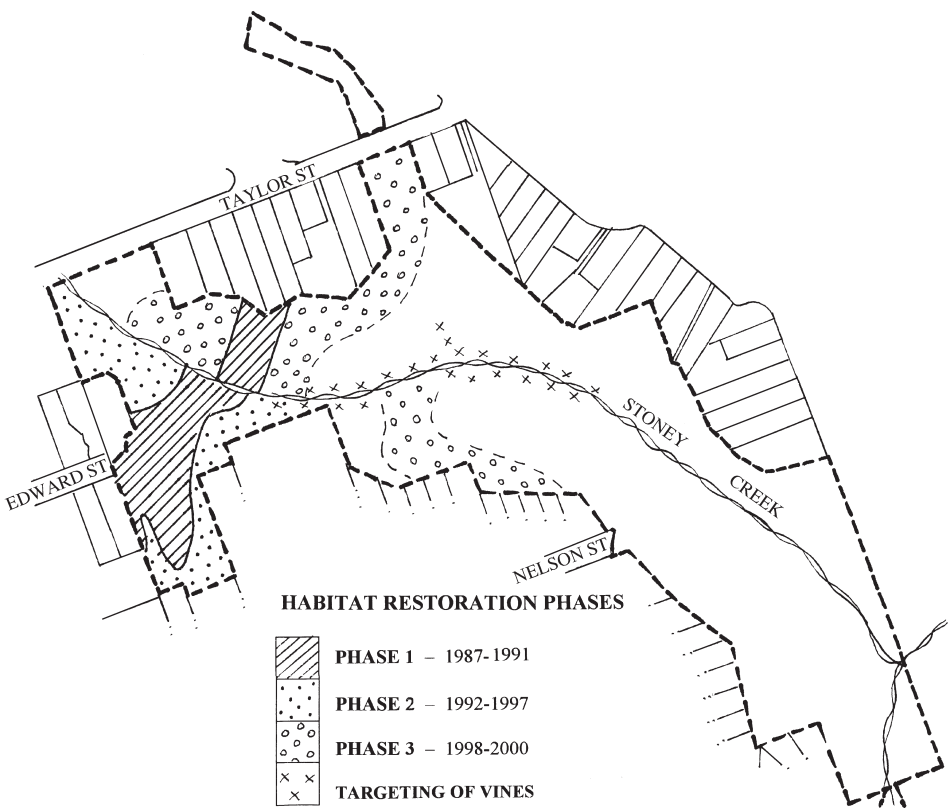

Figure 2. Habitat restoration areas, representing the various funding phases for the works carried out at Flying-fox Reserve, Gordon.

Supplementary planting

Techniques other than weed control were also used. During phase 1 and early in phase 2, tubestock tree and shrub seedlings grown from locally collected seed were planted, in case the sites had no capacity for natural regeneration. In hindsight, much of this effort was wasted as regeneration did occur. Buchanan (1985) stated that Blackbutts were unlikely to survive under the changed conditions and recommended that Turpentines and Blue Gums (*Eucalyptus saligna*) be planted as replacement canopy species. In phase 3, planting or transplanting of seedlings has been limited to canopy species: Blue Gums, Turpentines and Coachwoods (*Ceratopetalum opetalum*).

Figure 3. Left: damaged Turpentine canopy in 1985, Ku-ring-gai Flying-fox Reserve, Gordon (photo: R. Buchanan). Right: recovering Turpentine canopy in 1995, same location (photo: N. Pallin).

Fire piles

Another technique that was being talked about in Sydney at the time, but about which little was known, was the use of fire. This was used for three reasons: to save the lugging of huge quantities of Lantana debris up to the street for costly removal by Council; because of the sheer volume of weed debris that inhibited germination and; to trigger the germination of any seed stored in the soil. After comprehensive weed clearance, random fire piles were placed away from tree trunks and sandstone outcrops. Each pile measured no more than 1 m high and was composed of dry Lantana and privet stems, much of it less that 20 mm in diameter. Ku-ring-gai Council or NSW Fire Brigade assisted in burning these piles in spring or autumn (September 1991, August/September 1992, September/October 1993, April 1995) on a day when the wind would not blow smoke to the flying-foxes or to the neighbours.

The following observations were made about the 27 piles burned in September 1991. Flame heights ranged from 2 to 4 m. The hottest fires burned furiously for 20 minutes and then died down and smouldered for several hours. The first pile was lit at 10.10 hours and all piles were put out completely by hosing by 14.30 hours. Smoke from the fires was very localized due to the dry nature of the piles and was not noticeable beyond the immediate area.

Progress and some regeneration surprises

Results came quickly after weed control. Mature Blackbutts and Turpentines whose canopies were previously dying back, began to resprout along the trunks (Fig. 3). Extensive banks of Lantana and privet were replaced with naturally regenerating groundcover species (Table 1); particularly Weeping Grass (*Microlaena stipoides*), basket grasses (*Oplismenus* spp.), native geraniums (*Geranium* spp.), Kidney Weed (*Dichondra repens*) and pennyworts (*Hydrocotyle* spp.). While the flying-foxes are not currently occupying the regenerating vegetation at the western end of the Reserve, the new generation of trees are filling gaps in the canopy to replace the many dead trees which have fallen in recent years. Turpentine seedlings have regenerated naturally in canopy gaps enlarged by falling dead trees. On the upper slopes, Blackbutt seedlings germinated on bare ground following weed clearing and pile burns (following a mass flowering of Blackbutts in the summer of 1994). These Blackbutts have now reached 8 m in height and continue to grow vigorously despite periodic defoliation by caterpillars.

In the areas where fire piles were used, a number of sclerophyll shrub species germinated despite the apparent long-term absence of parent plants in the above-ground vegetation (Fig. 4). Seeds of these species had presumably been stored in the soil for decades, showing that the reintroduction of these species from other areas was unnecessary. A volunteer used quadrats to collect quantitative data from six fire piles and from randomly selected adjacent unburnt areas of a similar size. An analysis of data using one-way ANOVA found that the average number of sclerophyll shrub species was significantly higher in the pile burn areas ($F = 53.57$; $P = 0.1$) compared with the unburnt areas. These species also occurred in significantly higher densities ($F = 53.57$; $P = 0.01$). The most abundant species in the burnt areas were the sclerophyll shrubs, Green Wattle (*Acacia parramattensis*) and Hop Bush (*Dodonaea triquetra*); with Flax-leaf Wattle (*Acacia linifolia*) and Rusty Petals (*Lasiopetalum ferrugineum*) occurring in lower numbers. Conversely, in the unburnt areas, native grasses were most abundant, particularly the basket grasses and Weeping Grass (*Microlaena stipoides*). On average, significantly higher numbers of native grass species were found in the six unburnt areas compared with the burnt areas ($F = 22.84$; $P = 0.01$) and these occurred in significantly higher densities ($F = 5.02$; $P = < 0.05$).

Overall, measurable progress has been made over the 15 years. The phase 1 and 2 areas which were initially classified as Weed Class 4, are now Weed Class 1, requiring decreasing maintenance weeding each year. The phase 3 areas are currently at Weed Class 2 or 3 and will be needing regular work to maintain them in the next couple of years. While these results are highly satisfactory, only approximately one-third of the larger Reserve has received treatment; and the untreated areas (particularly the eastern section of the Reserve, beyond the flying-fox colony) is deteriorating rapidly due to continuing storm-water impacts, weed invasion and lack of fire to stimulate sclerophyll recovery.

Regeneration within the colony site 1998–99

In 1985, some of the area currently occupied by the flying-foxes would have been

Table 1. Native species which regenerated on the site after weed removal

Herbaceous species
*Austrostipa pubescens**
Carex appressa
Centella asiatica
Dianella caerulea
Echinopogon caespitosus
Entolasia marginata
Entolasia stricta
Gahnia sp.*
Geranium homeanum
Glycine sp.*
Gnaphalium sphaericum
Gonocarpus teucrioides
Imperata cylindrica
Isolepis inundatus
Juncus usitatus
*Lepidosperma laterale**
Lomandra longifolia
Lomandra multiflora
Microlaena stipoides
Opercularia aspera
Oplismenus sp.
*Panicum simile**
Persicaria spp.
*Plantago debilis**
Pseuderanthemum variabile
Polymeria calcyina
Poranthera microphylla
Pratia purpurascens
Rubus hillii
Sigesbeckia orientalis
Schelhammera undulata
*Senecio hispidulus**
Veronica plebeia
*Wahlenbergia gracilis**
Xanthosia pilosa
Xanthosia tridenta
Youngia japonica

Ferns
Adiantum hispidulum
Blechnum cartilagineum
Calochlaena dubia
Christella dentata
Cyathea australis
Doodia aspera
Doodia caudata
Hypolepis muelleri
Pellaea falcata var. *falcata*
Pteris tremula

Climbers
Eustrephus latifolius
Geitonoplesium cymosum
*Hardenbergia violacea**
Hibbertia aspera
Hibbertia dentata
*Kennedia rubicunda**
Morinda jasminoides
Pandorea pandorana
Smilax glyciphylla
Tylophora barbata

Shrubs
*Acacia linifolia**
*Acacia longifolia**
*Acacia longissima**
Breynia oblongifolia
*Dodonaea triquetra**
*Grevillea linearifolia**
*Lasiopetalum ferrugineum**
Leucopogon juniperinus
Notelaea longifolia
*Ozothamnus diosmifolius**
*Platysace lanceolata**
*Platysace linearifolia**
Polyscias sambucifolius
*Pultenaea flexilis** (died later)
*Zieria pilosa**
*Zieria smithii**

Trees
*Acacia parramattensis**
Alphitonia exclesa
Acmena smithii
*Callicoma serratifolia**
Ceratopetalum apetalum
Eleaocarpus reticulatus
Eleaocarpus kirtonii
Eucalyptus pilularis
Ficus coronata
Ficus fraseri
Ficus rubiginosa
Glochidion ferdinandi
Pittosporum undulatum
Polyscias elegans
Syncarpia glomulifera
Syzygium spp.
Trema aspera

* Species whose germination was significantly improved by the addition of pile burns.

classified as open forest vegetation (Specht 1970) as it was dominated by Blackbutts (although, even then, 'in a poor state of health'). Black She Oak (*Allocasuarina littoralis*) formed the next layer, with an understorey of sclerophyllous shrubs (Buchanan 1985). Since then, *Trad*, Lantana, Madeira Vine and other weeds have invaded from Stoney Creek and advanced eastwards with the flying-foxes.

Removal of Trad, Lantana and Madeira Vine in July–September 1998 resulted in natural regeneration of native species within 1 year. These include nine herb, three grass, four fern, six vine, six shrub and nine tree species, with some surviving plants having resprouted. The shorter length of time that the ground in this area has been blanketed by weed may be significant in the speedy recovery of the understorey. We have yet to find what mix of understorey species will survive under a flying-fox colony on this site when Trad is excluded. Flying-fox faeces appeared to cause burning on the leaves of many plants, including Turpentine seedlings. Turpentine and Blue Gum seedlings were planted outside the canopy of existing roost trees and were protected initially with plastic guards. In 12 months, some Blue Gums had grown to 4 m and Turpentines to 1.5 m. Approximately 10 per cent of the planted seedlings had died.

Fauna diversity

The KBCS has collected the available information (plus its own observations) on the approximate area occupied by the flying-foxes since 1972 and has marked all this information on maps supplied by Ku-ring-gai Municipal Council (Fig. 1). These data will be recorded on Ku-ring-gai Council's geographical information system.

Bush regenerators recorded their observations of other fauna seen on the site, compiling a fairly comprehensive fauna list. An unusual dung beetle (*Cephalodesmius armiger*) which feeds on plant material instead of dung was identified with the assistance of the Australian Museum and CSIRO. As the vegetation became more diverse, moths, butterflies, frogs, Eastern Water Dragons (*Physignathus lesueurii*), skinks, wrens (*Malurus* sp., *Sericornis frontalis*), warblers (*Gerygone mouki*), fantails (*Rhipidura* spp.) and the Eastern Spinebill (*Acanthorhynchus tenuirostris*) became more common. The Eastern Yellow Robin (*Eopsaltria australis*), Golden Whistler (*Pachycephala pectoralis*) and Satin Bower Birds (*Ptilonorhynchus violaceus*) occupy the dense vegetation along the creeks. A Superb Lyrebird (*Menura novaehollandiae*) is seen periodically by regenerators and neighbouring residents. Native vertebrate species listed during bush regeneration or site inspections include six mammals, 69 birds, 12 reptiles and three common frogs. Two threatened frog species (*Mixophyes iteratus* and *Pseudophryne australis*) were recorded in 1972 but have not been reported since.

A pair of Powerful Owls (*Ninox strenua*) reside in the valley, feeding on flying-fox (Kavanagh 1993) and Ring-tail Possum (*Pseudocheirus peregrinus*; N. Pallin, pers. obs., 1999). Sea-eagles (*Haliaeetus leucogaster*) and the Diamond Python (*Morelia spilota* ssp. *spilota*) are predators of flying-foxes and are seen occasionally. In 1989, traps were set over four nights for terrestrial mammals, resulting in the capture of Black Rats (*Rattus rattus*) and two male Brown Antechinus (*Antechinus stuartii*; R. & A.

Figure 4. Top: prior to treatment in 1986, Lantana reached into the canopy (photo: N. Pallin). Middle: same view during phase 2 (1993) shortly after weed removal and during the burning of fire piles [note, second tree has fallen; (photo: M. Schofield)]. Bottom: native understorey regeneration in 1997, 4 years after treatment (photo: N. Pallin).

Williams, unpubl. data, 1989). With the change in the vegetation during the primary stage of bush regeneration, there was a danger that feral birds, such as the Common Mynah (*Acridotheres tristis*) might invade. Fortunately, this has not occurred.

Contributions from the flying-foxes

The largest impact of flying-foxes on their roosting habitat is the contribution of nutrients to the colony site. Wiley (1988) conservatively estimated that they contributed 3 kg phosphorus per ha per year in their droppings. Treadwell (1996) found soil phosphorus levels under the flying-fox colony of 429 ± 242 p.p.m. in summer and 496 ± 240 p.p.m. in winter. These levels were already two- to four-fold the amount found in healthy bushland soils of a similar type (Beadle 1962) and were more than double the amount of 189 ± 77 p.p.m. found under the colony by Wiley, 8 years earlier. Treadwell (1996) concluded that a total of 27 kg per ha had been added to the colony site since 1988. Both studies concluded that the additional nutrients were contributing to the weed growth, particularly the dense ground cover of Trad. Treadwell concluded that the difference in phosphorus measurements between summer and winter was a result of the Trad utilizing the nutrient for growth in summer but not in winter.

The bats have also had an effect on the floristics of the site. In the areas used by the bats, an array of species known to be part of the flying-fox diet (as well as the usual array of herbaceous weeds) germinated after comprehensive weed removal exposed the soil to sunlight. These, mainly rainforest-type species, included Sandpaper Figs (*Ficus coronata* and *F. fraseri*), Port Jackson Fig (*F. rubignosa*), a few Moreton Bay Figs (*F. macrophylla*), Lilly Pillies (*Acmena smithii, Syzygium oleosum* and *S. paniculata*), Blue-berry Ash (*Elaeocarpus reticulatus*), Pigeon-berry Ash (*E. kirtonii,* although not a known diet plant), Red Ash (*Alphitonia excelsa*), Giant Stinging Tree (*Dendrocnide excelsa*), Plum Pine (*Podocarpus elatus*), many species of exotic palms, vines such as *Cissus* spp., *Morinda jasminoides*, the exotic Mulberry (*Morus nigra*) and huge numbers of the exotic, Tree Tobacco (*Solanum mauritianum*). Flying-foxes transport seeds of some of their diet plants, either in their mouths (for seeds greater than 4 mm in diameter) or their digestive tract, for small seeds (Eby 1996).

Some Australian native plants which were clearly not locally indigenous were readily removed along with exotics, with others requiring careful analysis to distinguish whether they were artefacts of nearby urban plantings or genuine extensions of the range of species occurring in rainforests

to the north or south of Sydney transported by flying-foxes. Seedlings of Mulberry, Tree Tobacco and palms were removed. It was concluded that *Ficus fraseri* represents an extension of range southward for this species. The Stinging Tree seedlings died. Although Moreton Bay Figs are prime roost trees at other colony sites, they do not naturally occur in the Sydney basin, so were removed. Pigeon-berry Ash grew to 6 m before its identity was confirmed, and the questions remain, 'where did it come from and how did it get there?'

Public attitudes to flying-foxes

An initial barrier to success was the lack of knowledge of flying-foxes among the general public, although this is clearly changing. Ku-ring-gai historical records contain a photograph of a bat shooting party taken early this century. When public money was spent purchasing land to protect the bat colony in the 1980s there was a deluge of antibat letters in the newspapers which displayed ignorance of these native animals and no knowledge of their ecological roles. Some residents near the Reserve objected vocally to the noise and smell of the animals but over the years these complaints have declined as residents gained a better understanding of their wild neighbours. Some prospective home buyers have even phoned KBCS for information on the bats and their possible impacts.

Public understanding and acceptance is crucial for long-term environmental conservation programmes. The KBCS has been presenting live, hand-reared flying-foxes to the public since 1985. This approach did more to change people's attitudes than words ever could. By seeing a flying-fox close up, many myths were dispelled. We could explain new information coming from bat researchers to people at fetes, to Scouts and Guides, community group meetings and even in the Council Chambers. KBCS took their presentation on the Grey-headed Flying-fox into schools, gaining curriculum approval from the Department of Education.

Other methods of spreading information include publishing the *Friends of Bats* newsletter, which keeps members up to date on bat issues and is now up to its 54th issue. The KBCS encourage people to view the evening exodus of the flying-foxes from an observation point at the nearby Rosedale Road bridge, which is spectacular on summer evenings. Here, pictorial signs explain the pollination and seed dispersal services provided by flying-foxes. More information is available on five educational signs at the nearby Kukundi Wildlife Shelter in Lane Cove National Park where the educational boards about flying-foxes are on permanent public display. While these programmes do much to change attitudes, a primary consideration is that visitor pressure is deflected away from the colony site and the regenerating vegetation in the Reserve.

The discovery, in 1996, of the flying-fox-borne virus, Australian Bat *Lyssavirus* which can only be contracted through bites and scratches from bats, has not helped KBCS efforts to promote a positive attitude towards bats. Indeed, requests for bat talks temporarily dropped after the discovery and, given the need for vaccination for bat handlers and its high cost, the number of people available to give talks has been slow to increase. Fortunately, however, the advent of the virus has not affected funding for the Habitat Restoration Project which continues with a Natural Heritage Trust grant (1998–2000) and Ku-ring-gai Bat Conservation Society members have maintained their moral and financial support.

Keys to success to date

While we are aware that our successes are relatively small compared with the size of the ongoing, broader, urban degradation problem, the most fundamental ingredient of success to date has been the support of the volunteer bush regenerators. A number have devoted more than 10 years to the project and collectively contributed approximately 1000 hours per annum. Furthermore, the contract bush regenerators employed on the project showed a willingness and enthusiasm for the project far beyond their monetary rewards, and were often prepared to exchange ideas with the volunteers during their lunch break. Both contract and volunteer bush regenerators have contributed their observations for the flora and fauna species lists for the Reserve. Volunteers also contributed to a census of flying-foxes in the valley, estimated weekly (December 1994–November 1997) by 'counting' the animals as they flew out of the valley at dusk. 'Counts' continue monthly, providing a comparative record of occupation of the site.

Another key to successful management is acknowledging that a regeneration programme must be sufficiently flexible to work with unpredictable natural events and seasonal opportunities. This periodic nature of regeneration was highlighted in the summer of 1998–99, for instance, when Coachwood underwent a spectacular flowering. Additional areas were cleared of Trad to take advantage of the massive fall of seed, an action which resulted in the germination of thousands of Coachwood seedlings. As these events do not occur annually, restoration programmes must be flexible enough to take advantage of these opportunities because the next event may be 5 or 10 years away.

Another essential ingredient has been the support of workers from other sites, such as Dr John Stockard who has considerable experience with both flying-foxes and regeneration at Wingham Brush in northern NSW. Scientists shared their knowledge of bats, freely giving their time and expertise to speak at the 'Friends of Bats' events which KBCS has held twice each year since 1987.

Last, but certainly not least, there has been good support from the land manager, Ku-ring-gai Council and from the NSW National Parks and Wildlife Service. Council continues to provide an annual allocation of $10 000 to maintain the increasing area of regenerating forest. A Voluntary Conservation Agreement was signed between Ku-ring-gai Municipal Council and the NSW Minister for Environment in 1991 to protect Ku-ring-gai Flying-fox Reserve in perpetuity. A grant under this agreement was used to install interpretive signage, gross pollution traps and conduct research in collaboration with the University of NSW on soils and radiotelemetry of rehabilitated flying-foxes following their release (Augee & Ford 1999).

Continuing challenges

A number of unique challenges have complicated the task of achieving the project's goals. One of these has been the difficulty of

Why we volunteer: Some of the longer-term volunteers tell their own story

Bat Colony volunteers taking a break from work in Area 4 in the early 1990s (clockwise from front left: Maree Treadwell, Nancy Pallin, Marjorie Beck, Elizabeth Hartnell, Anne Ringwood, Roma MacGregor, Margaret Beavis and Eileen Davies).

Tuesdays are sacrosanct to the workers at 'the Bat Colony'. Every week for 12 years so far, small numbers of volunteers have been meeting on site to transform it from a highly weed-infested site to what is now a healthy-looking bushland area with a strong native understorey.

Apart from the current team of 10, 67 volunteers have assisted at Flying-fox Reserve over the years collectively contributing approximately 1000 hours per annum. A number have devoted more than 10 years to the project.

Elizabeth Hartnell, one of the original team and still working after 12 years, remembers a time when Lantana was so thick that the team had to make tunnels to get to work. 'I remember one time I was late and got myself lost under the Lantana. I had to just go back up hill to find my way out. When we gradually cleared the Lantana nothing was growing except the mature native trees. But before long, there was the miracle of seeing natives germinating. That is the joy that drives us, because the native trees are so important to the canopy.'

'You get some inner satisfaction and peace in going down and just "bush regenerating". We have some very good talks, and jokes and fun. But also if you are not wanting to talk with someone, it is very easy not to. And you see the way the area changes with the response of the different plants over different seasons. And there are also birds and an awful lot of invertebrates to which we draw each other's attention, little moths or butterflies, spiders.'

Margaret Beavis, another 12-year volunteer, gets satisfaction from seeing the 'good' bush come back again in an area that was degraded. 'I get a big thrill out of that. What I am interested in is the bush becoming a self-supporting, varied system, with as much diversity as we can reasonably maintain. I don't go in for planting. I just prefer that things happen naturally. It's a delight to look back at that now. You have an image at the back of your mind of what it looked like then. And to see it now is just an absolute joy. And you realize that it's part of you by now, because you know every inch of the way. We really have battled there because it was so degraded before.'

'And I've met some really good friends there. That meant a lot to me. We talk about all sorts of things, from palaeontology, languages, travels, politics, and operas to, of course, environmental issues. Always interesting.'

Like many others, **Gerda Cohen** is mainly motivated to help the bats. 'The unusual thing is they live so close to us. It is so satisfying that their home can be so close to our home, as if they trust us to look after them. The place was so terribly infested with weeds. And we actually see it from month to month. When we come back to a site on which we worked we just can't believe how wonderful it is — what a response the bush gives to our work.'

'When I work, I prefer to be silent and have silence around me. So everybody finds something that they want, whether it is companionship or solitude. But what is reassuring is that you actually don't need to do a big chunk of work at a time. You just do the little bits and the little bits eventually join. It is the love of the work, as well and you know you can make a difference.'

Making a difference also depends upon the drive and inspiration of the team leaders — and the success of the project is in no small measure due to the guidance and inspiration of **Nancy Pallin**. 'It's actually very exciting. The world might appear to be falling apart but I think there's a huge number of people saying, "Well, hang it. I'm not going to let that happen." By the time I'm dead, it won't matter. But it will matter for the younger people. I say to them. "Let's do it." And they look at you as if you are a bit mad. But next time they see you they say "You're right, you know. We've got to do it" So, it's good stuff.' ™

addressing urban storm-water discharges that were repeatedly disturbing treated sites and delivering fresh weed seed, road gravel, silt and litter from surrounding streets. Three experimental gross pollution traps have been placed in street drains to collect material before it enters the Reserve. When the traps were cleaned they were found to contain 60% soil fractions, 35% vegetative matter and 5% plastic bottles and other litter (L. Hardy, Ku-ring-gai Council, pers. comm., 1999). The solids block the water channel, causing further scouring and deposition across hillsides which are not natural drainage lines. Regular cleaning of the traps will prevent this problem, but is a cost the community as a whole must bear to protect urban bushland from further deterioration.

Arguably, the most important challenge is that major sources of exotic invasive trees and shrubs still exist in the broader Stoney Creek catchment and are readily redispersed by native fauna, particularly Currawongs (*Strepera graculina*; Buchanan 1989). Although Ku-ring-gai Council has policies for control of noxious and environmental weeds, the majority of residents are only able to identify a couple of them and are mostly ignorant of weed dispersal or effective weed removal methods. Some progress was made with a pilot 'Backyard, bush-friendly' programme conducted in 1995–96 by Ku-ring-gai Council and funded by the Voluntary Conservation Agreement grant. Further personal contact by KBCS members has convinced a few more neighbours to replace their weeds with local indigenous species but progress has been patchy.

A broad-scale environmental education programme is needed to involve the majority of landowners in weed removal and replacement with locally indigenous flora, from the ground covers to the treetops. Until the landscape scale weed problem is resolved the Habitat Restoration Project will have to continue with considerable annual maintenance costs.

A 'take home' message

Flying-foxes not only need colony sites in which to roost, but also food resources across the landscape. The continuing loss of indigenous trees, especially Blue Gums, Blackbutts, Turpentines, ironbarks, bloodwoods and angophoras (caused by further development in surrounding suburbs) is a loss of their food resources. The KBCS believes that, in the same way public support has been harnessed for the flying-foxes, it can also be stimulated for restoration of native vegetation in the catchment. If residents were shown that low maintenance indigenous gardens could save them from the drudgery of mowing and the costs of watering — and give them the delights of wrens, fantails and water dragons outside their windows — habitat restoration could take place across whole valleys, even in an urban setting.

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