Tree-planting to conserve flying-foxes and reduce orchard damage

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ABSTRACT

This paper outlines a tree-planting scheme with the dual aim of conserving Grey-headed Flying-foxes *Pteropus poliocephalus* and reducing damage to fruit crops. Grey-headed Flying-foxes experience resource bottlenecks during winter and spring because of past habitat clearing and the erratic flowering of eucalypts. When there is broad-scale failure of native foods in spring, flying-foxes raid orchards for ripening exotic fruit. These events are compounded by spring births in flying-foxes and potentially greater mortality from shooting in orchards. Dual benefits to flying-foxes and orchardists could be achieved by replanting spring flowering tree species lost from past clearing. To aid this process we develop winter and spring species lists, prioritized on the basis of past clearing and their likelihood of contributing reliable food sources for flying-foxes in the future. We discuss ideas relating to where trees should be planted, and recommend that areas lacking commercial orchards could be targeted for spring plantings and that local decoy plantings should be avoided.

Introduction

Tree-planting schemes are receiving an ever-increasing focus to alleviate a range of environmental problems in Australia. Such schemes vary from commercial enterprises (including farm forestry) where timber production is the goal, to community groups, such as Landcare, which aim to reduce soil erosion and improve local wildlife habitat (e.g. using corridors). Currently, economic incentives are driving planting programs in cleared landscapes for carbon sequestration (carbon credits) and salinity reduction (salinity credits). These schemes often use local tree species, but without giving a detailed consideration to their potential use by fauna. Exceptions are tree-planting schemes for high profile species, such as the Koala *Phascolarctos cinereus,* where a local understanding of their food requirements enables a foraging resource to be planted.

We consider that there is considerable potential for tree-planting schemes to supplement the decreasing foraging habitat of the Grey-headed Flying-fox *Pteropus poliocephalus*. One of its main threats is habitat loss through vegetation clearance (Eby *et al.* 1999). In particular, selective clearing of coastal areas and fertile valleys has left Grey-headed Flying-foxes with seasonal periods of food shortage (Eby 1995), which are exacerbated by the unpredictable nature of blossoming in eucalypts (Law *et al.* 2000). Spring (September, October and November) has been identified as the leanest period for Grey-headed Flying-foxes (Parry-Jones and Augee 1991; Eby 1995), with good spring flowering normally dependent on good autumn rains (Law *et al.* 2000). This situation is compounded by spring births and lactation in the Grey-headed Flying-fox (Martin and McIlwee 2002). Winter food shortages also impact on this species as forest clearing associated with urban and rural development in coastal areas has reduced the abundance of winter-flowering trees (Eby *et al.* 1999). Winter can be a time of high demands for the Grey-headed Flying-fox because of increased thermoregulation costs and the fact that the number of food species available at this time is restricted.

The opportunity to remedy these resource bottlenecks can draw impetus from the fact that orchardists often face considerable crop losses from foraging flying-foxes during spring. The greatest depredation by flying-foxes usually occurs in spring/early summer when commercial fruit is ripening,

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especially if the bats' natural food has failed (Eby 1995). These two inter-related problems combine to highlight the benefits of planting spring flowering/ fruiting trees as a potential solution for flying-fox conservation and mitigation of crop losses in orchards. Planting winter food species may not benefit orchardists, but it is expected to benefit flying-fox conservation.

The aims of this paper are therefore to offer lists of key winter and spring food trees for Grey-headed Flying-foxes in New South Wales (NSW), and suggest tree-planting strategies that may enhance conservation and alleviate crop damage. Our focus is on landscapes that are already cleared, where trees will not usually recover by means of natural regeneration. Only trees that are locally indigenous have been suggested. We briefly discuss related issues such as the influence of drought on food trees and provide suggestions for planting in relation to the location of flying-fox camps and orchards. It should be stressed here that while replanting food trees to fill resource bottlenecks makes good ecological sense, the success of decoy plantings in minimizing fruit loss in orchards is untested. However, the idea is supported by observations of Grey-headed Flying-foxes switching to commercial fruit when native foods fail and leaving again when alternative native foods become available (Eby 1990).

Flowering times and the importance of food species in the diet of Grey-headed Flying-foxes are derived from Clemson (1985), Eby (1995), Somerville (1999), Law *et al.* (2000) and the authors' personal observations. It is likely that additions to our list will be made as the diet of flying-foxes becomes better understood in different parts of their range. As much as possible, the flowering times provided reflect variations that occur across the species' range (see Somerville 1999).

Issues to Consider in Selecting Tree Species

The effectiveness of a tree-planting scheme for Grey-headed Flying-foxes will be affected by the amount and regularity of food produced by the program and by the attractiveness of the food to the bats. Different tree species vary in the quality and quantity of both nectar and pollen (Clemson 1985). In this paper we omit species used infrequently by flying-foxes, although whether this is due to lack of nectar or pollen is not usually known.

Nectar and pollen from blossoms are the main native food resource used by flying-foxes in winter and spring (Parry-Jones and Augee 1991). Native fruits produced in subtropical rainforests are also used extensively by Grey-headed Flying-foxes (Eby 1995; Eby 1998), but in NSW the majority ripen from summer to autumn (Holmes 1987). Figs differ in that individuals of many species fruit asynchronously, but relatively low volumes are produced during winter and spring. Common species that frequently produce fruit crops in winter and spring include the White Fig *F. virens* and Strangler Fig *F. watkinsiana*. These species occur in northern NSW in low altitude and riverine rainforest (Floyd 1989). Our remaining discussion focuses on blossom production.

Detailed information relating to the factors that influence blossom production is mostly restricted to northern NSW (Law *et al.* 2000), which represents the core of the range of Grey-headed Flying-foxes. Much of the following discussion hinges on this information. In northern NSW, different tree species blossom sequentially throughout the year to provide flying-foxes with a potentially year-round food supply (Fig 1). Yet it is important to remember that eucalypts provide a very patchy blossom resource, both in time and space. Blackbutt *Eucalyptus pilularis* is a prime example as it forms floral buds every 1-2 years, but it occasionally takes over 5 years for buds to flower (Law *et al.* 2000). Although Blackbutt is a food species for Grey-headed Flying-foxes, it flowers irregularly, and potentially in any month (Law *et al.* 2000), and therefore it would not be considered a priority species to plant for flying-foxes.

An additional consideration is to avoid species that only occasionally produce large food crops. For example, the Rough-barked Apple *Angophora floribunda* flowers on average every four years in northern NSW (Law *et al.* 2000). Although flying-foxes will forage at this resource under natural conditions, its unreliable flowering reduces its priority for planting. By contrast, Swamp Mahogany *E. robusta*, Forest Red Gum *E. tereticornis*, Northern Grey Ironbark *E. siderophloia* and Broad-leaved Paperbark *Melaleuca quinquenervia* are examples of north coast species that flower heavily at regular, although not always annual, intervals (Law *et al.* 2000).

Consideration should also be given to matching local site conditions with species to be planted. For instance, *E. tereticornis*, which is normally found on fertile flats and low-lying areas, tends to flower poorly on upper slopes (Law *et al.* 2000). Similarly, Coast Banksia *Banksia integrifolia*, which is a reliable winter resource, should be

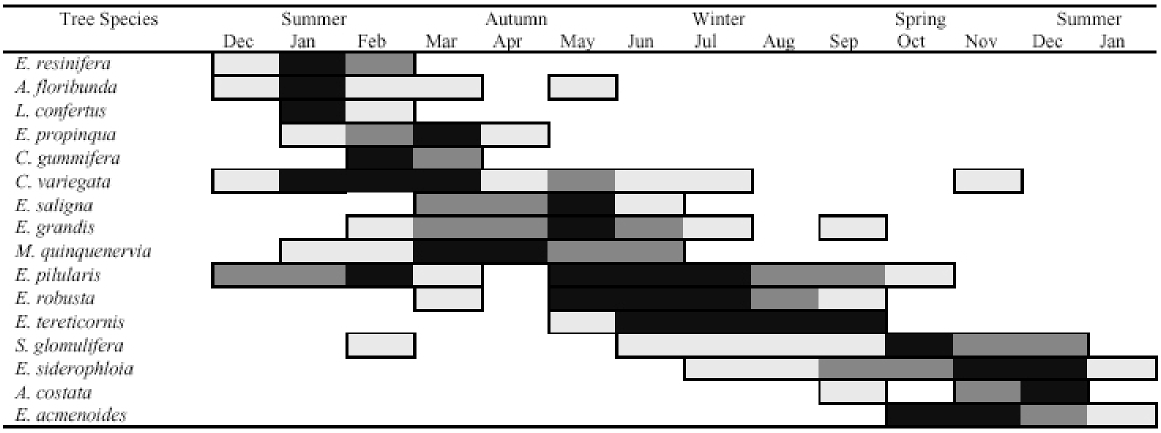

Fig 1: An illustration of flower continuity in northern NSW. Flowering seasons of 16 species of myrtaceous trees were collated over 10 years from 23 study sites on the north coast of NSW (taken from Law et al. 2000). These species are all food trees of Grey-headed Flying-foxes, but they do not represent a comprehensive list. Dark stippling represents periods of frequent flowering in that month, intermediate stippling represents regular flowering and light stippling occasional flowering. Months where < 5 % of flowering events occurred have been omitted.

planted at coastal sites. Landcare and local government can assist with information on appropriate site conditions.

When prioritizing species for tree-planting it is important to consider whether drought reduces blossom production. This is especially relevant if drought-induced failure of native food in spring leads to greater commercial fruit losses (Eby 1995). Among eucalypts, drought-sensitivity can be expressed as poor flowering due to floral bud abortion, bud dormancy or reduced bud formation. These effects are most noticeable during drought in Northern Spotted Gum *Corymbia variegata*, White Mahogany *E. acmenoides*, Flooded Gum *E. grandis* and Red Mahogany *E. resinifera* (Law *et al.* 2000). Among these species, only *E. acmenoides* flowers consistently in spring (Fig. 1). Although it is possible that nectar production rather than blossom abundance may be reduced in drought, limited research in this area suggests that heavy nectar flows in eucalypts can follow dry periods (Wykes 1947; Porter 1978). Planting in riparian sites, low-lying areas or even around dams may increase blossom production in some species (Wilson and Bennett 1999).

Species will vary in the length of time between planting and flowering. Some species of eucalypt are capable of flowering at four years of age (Bridges 1983), although a period of at least 10 years would be expected before a substantial floral resource is established. Clearly, flower abundance will increase with the size and age of the tree, although this is poorly documented for most species (Law *et al.* 2000). This lack of information prevents us from recommending specific species that flower early.

Priority Tree Species

Species known to produce food for flying-foxes in spring and winter are listed in Tables 1 and 2, respectively. There are more species that flower in spring than winter, but many of the former are unreliable. The north coast supports the greatest number of tree species that produce food during both winter and spring, indicating that a mix of species are available for planting at different sites (Table 1). Few winter and spring food species occur in the south of NSW (although see Kavanagh 1987 for flowering times of other tree species not known to be used by flying-foxes). Given the extensive clearing of *E. tereticornis* in this region (Lunney and Leary 1988), this species would rate as a high priority for planting on alluvial flats of the south coast. Vegetation clearance has been particularly severe west of the Great Dividing Range, with as little as 24 % remaining in the central west (Sivertsen 1995; Norton 1996; State of the Environment Advisory Council 1996). In this area, *E. melliodora* and *E. albens* are among the few winter and spring food plants that flower reliably every few years (Table 1; Table 2). These species typically have a patchy flowering pattern, so that large areas spread across different regions are needed to ensure reliable blossom.

A similar pattern of clearing has occurred in the central coast and Sydney regions of NSW. For example, loss of over 90 % of Cumberland Plain Woodland in the Sydney Basin (Benson and Howell 1990) has resulted in a dramatic

Table 1: Key tree species providing flowers during the September-December bottleneck period, together with regions where they occur naturally. * indicates very irregular flowering.

Species	Months	Region
		Coast
Forest Red Gum *Eucalyptus tereticornis*	Winter-October	South, Central, North
Old Man Banskia *Banksia serrata*	December-Summer	South, Central, North
Red Ironbark *E. fibrosa**	November-Summer	South, Central, North
Turpentine *Syncarpia glomulifera*	September-October	South, Central, North
Grey Ironbark *E. paniculata*	September-Summer	South, Central
Red Mahogany *E. resinifera*	November-Summer	South, Central
Parramatta Red Gum *E. parramattensis**	November-Summer	Central
White Mahogany *E. acmenoides*	October-November	Central, North
Yellow Bloodwood *E. eximia*	August-October	Central
Cabbage Gum *E. amplifolia*	November-December	Central, North
Brush Box *Lophostemon confertus*	November-Summer	North
Narrow-leaved Red Gum *E. seeana*	November-December	North
Northern Grey Ironbark *E. siderophloia*	November-December	North
Black Bean *Castanospermum australe*	October-December	Far North
Silky Oak *Grevillea robusta*	October-December	Far North
		Tablelands
Blakely's Red Gum *E. blakelyi**	October-December	South, Central, North
Yellow Box *E. melliodora*	September-Summer	South, Central, North
New England Blackbutt *E. andrewsii*	October-December	North
		Western Slopes
Blakely's Red Gum *E. blakelyi**	September-December	South, Central, North
Tumble-down Red Gum *E. dealbata**	September-October	South, Central, North
Yellow Box *E. melliodora*	September-Summer	South, Central, North
Red Ironbark *E. fibrosa*	Summer	Central, North
Narrow-leaved Ironbark *E. crebra**	October-November	Central, North
River Red Gum *E. camaldulensis**	November-Summer	Western Rivers

Table 2: Key tree species providing flowers during winter, together with regions where they occur naturally. *indicates very irregular flowering.

Species	**Months**	**Region**
		Coast
Blackbutt *Eucalyptus pilularis* *	Highly variable	South, Central, North Coast
Broad-leaved paperbark *Melaleuca quinquenervia*	Autumn-June	Central, North Coast
Coast Banksia *Banksia integrifolia*	Autumn-September	South, Central, North Coast
Forest Red Gum *Eucalyptus tereticornis*	June-September	South, Central, North Coast
Spotted Gum *Corymbia maculata* *	April-September	South, Central Coast
Swamp Mahogany *Eucalyptus robusta*	May-August	Central, North Coast
		Western Slopes
White Box *Eucalyptus albens*	Autumn-September	South, Central, North West Slopes

Table 3: Priority species for planting by region and by season. Only those providing food in the key periods of winter and spring are listed. Priority has been based on species that have been extensively cleared and that regularly produce food for flying-foxes.

Region	Season
Far South Coast (Eden-Narooma)	
Forest Red Gum	Spring
South Coast (Narooma-Illawarra)	
Coast Banksia	Winter/early Spring
Swamp Mahogany	Winter
Forest Red Gum	Spring
Central Coast and Sydney	
Coast Banksia	Winter/early Spring
Swamp Mahogany	Winter
Forest Red Gum	Spring
Grey Ironbark	Spring
Yellow Bloodwood	Spring
North Coast	
Coast Banksia	Winter/early Spring
Forest Red Gum	Winter/Spring
Swamp Mahogany	Winter
Black Bean(Far North Coast)	Spring
Narrow-leaved Red Gum	Spring
Silky Oak (Far North Coast)	Spring
Northern Tablelands	
Yellow Box	Spring-Summer
Central Tablelands	
Yellow Box	Spring-Summer
North-west Slopes	
Red Ironbark	Winter/Spring
White Box	Winter
Yellow Box	Spring
Central-west Slopes	
White Box	Winter
Yellow Box	Spring

reduction in winter and spring food for flying-foxes from *E. tereticornis* and Spotted Gum *C. maculata*. Parry-Jones and Augee (1991) have documented a high incidence of exotics, and sometimes stone fruit, in the spring diet of Grey-headed Flying-foxes in Sydney. Restoration of Cumberland Plain Woodland has the potential to change this pattern.

Tree species selected as high priority for planting are listed in Table 3. Priorities have been separated into regions where the different species occur and also where flowering patterns may vary. Priority tree species were selected on the basis that they have been extensively cleared and thus would benefit from revegetation programs. They are also species that flower reliably and could support or induce large movements of flying-foxes to the new resource.

Where to Plant?

We suggest two planting strategies for increasing food for flying-foxes in spring and winter. Firstly, a strategy that aims to increase the amount of native food available throughout their range. Initially, we recommend that clearing of remaining spring and winter habitat is curtailed. We then recommend replanting of native spring and winter food sources throughout the range of Grey-headed Flying-foxes, focusing on trees with regular flowering patterns (Table 3). Most plantings would be accessible to Grey-headed Flying-foxes as their camps occur regularly along the coastal areas of NSW and they forage up to 40 km from camps (Eby 1991). Given that isolated trees in paddocks and backyards are fed on by flying-foxes, the shape of plantings (e.g. linear) will not be a major influence on foraging. However, large areas with minimal edges would maximize benefits to other components of biodiversity.

Mixed species or "ecological restoration" type plantings would be most beneficial to other components of biodiversity. A useful model of habitat enhancement for a threatened species that has wider benefits to biodiversity is the extensive planting of fig species in northern NSW, targeting the recovery of Coxen's Fig Parrot. This is a cooperative venture by NPWS, State Forests of NSW, Byron Shire Council and the Big Scrub Rainforest Landcare Group. The figs being planted will be used by a range of fauna species.

We do not recommend planting food trees in the immediate neighbourhood of orchards. Local plantings would lure flying-foxes into the vicinity of orchards. Even assuming that native foods are nutritionally more beneficial and are preferred by flying-foxes (Steller 1986), these bats are highly territorial at food trees and it is possible that subordinate bats would be forced to feed at less preferred sites.

The second strategy is specifically directed at the problems faced by orchardists. It aims to attract significant numbers of animals away from commercial fruit growing areas during spring. This could be achieved by substantial plantings of key spring species in areas that are not major commercial fruit growing areas. Target areas for planting flying-fox attractive trees should avoid the extensive fruit growing areas on the north coast, central coast and Sydney region, primarily leaving the south coast, tablelands and western slopes. Two examples would be planting *E. tereticornis* as a spring resource on alluvial flats on the south coast, e.g. in the Bega valley and planting *E. melliodora* as a spring resource on the central and northern tablelands and north-west slopes, e.g. in the Liverpool Plains catchment. The south-west slopes is considered to provide marginal habitat for Grey-headed Flying-foxes, although this may well be an artifact of extensive historical clearing. Our strategy assumes that large-scale plantings would lure bats away from orchards, either through the release of large quantities of attractants (e.g. volatiles released during nectar production) or via information exchange within flying-fox camps. Grey-headed flying-foxes are well known for moving hundreds of kilometres in response to mass flowering events (Eby 1991).

Fast-tracking Tree Planting

Although some eucalypts flower when reasonably young, there will still be a delay of several years between the time when seedlings are planted and a significant blossom resource is produced. We therefore suggest that efforts be made to fast-track planting. Fast-tracking tree planting for flying-foxes could be achieved by enhancing existing schemes. Catchment Committees, Landcare, Greening Australia and local councils are groups where tree species presented in this paper could be selected and incorporated into local plans. There is also scope for considering biodiversity in commercially driven schemes. Planting for carbon credits is likely to increase rapidly in the future and there is a strong case for selecting species that not only sequester carbon, but also maximise biodiversity spin-offs. In salinity prone areas west of the Great Dividing Range, a variety of tree species are being planted (NSW Salinity Strategy 2000). Where possible, the NSW government is aiming for biodiversity benefits in conjunction with reduced salinity (NSW Salinity Strategy 2000). While tree species for salinity control are still being selected and researched, on the north-west slopes Yellow Box *E. melliodora,* White Box *E. albens* and River Red Gum *E. camaldulensis* are already being planted. There is less scope for flexibility in varying the hardwood tree species commercially planted for timber production in NSW as four species are the focus for north coast NSW: Blackbutt *E. pilularis*, Northern Spotted Gum *C. variegata*, Flooded Gum *E. grandis* and Dunns White Gum *E. dunnii*. These are all food trees of flying-foxes, but none flower reliably in spring or winter.

Measuring Success

All management plans should consider how their success or failure can be measured. Our strategy to plant priority food trees for Grey-headed Flying-foxes, with the dual aim of benefiting flying-foxes and reducing crop losses at orchards, could be measured in two ways. The first would be to monitor increments in the area (ha) of priority food trees planted, preferably by keeping records of planting schemes, but also through remote sensing and GIS mapping. This information should then be related to two further sources of information. First, documentation of a change in diet of Grey-headed Flying-foxes would indicate that the bats are using the newly planted food. Sydney would be one location for such work as the bats' diet has been previously well documented in that area, with known proportions of fruit in the diet during spring (Parry-Jones and Augee 1991). However, our strategy for orchardists would be to establish large-scale plantings outside of this area. Dietary studies would therefore be most useful at camps on the south coast or the western slopes. Second, accurate records of crop losses to flying-foxes (e.g. in dollars) could be maintained, so that changes in flying-fox management and its influence on orchardists can be measured. Each of these actions is potentially costly, but without this information we will be left unsure about the effectiveness of tree planting for flying-foxes and orchardists.

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