Grey-headed Flying-foxes in orchards: a collaborative project on damage estimates, contributing factors and mitigation strategies – triumphs and tribulations of flying-fox conservation and management in NSW

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ABSTRACT

The Grey-headed Flying-fox, *Pteropus poliocephalus*, is listed as a threatened species in NSW, Victoria and nationally. The Grey-headed Flying-fox is a key species in maintaining forest ecosystems through the pollination of native trees and the dispersal of rainforest seeds. This threatened species is unique in that it is also recognised as a horticultural pest, predominantly in coastal orchards of south-eastern Australia. In times of native resource (pollen, nectar and rainforest fruits) shortage, flying-foxes are known to utilise commercial fruit crops. As such, the species is affected by control techniques employed by horticulturists to mitigate flying-fox damage, including shooting and netting.

The NSW Department of Environment and Climate Change and the NSW Department of Primary Industries are working collaboratively to investigate flying-fox damage to commercial crops, quantify the levels of flying-fox damage (temporally and spatially), determine the factors contributing to trends in crop damage, and assess the effectiveness of mitigative measures employed by horticulturists to reduce flying-fox damage. The project is funded for two financial years through the Australian Government's Natural Heritage Trust Strategic Reserve funding and State Government contributions (cash and in-kind), and addresses several recovery actions of the draft National Recovery Plan for the Grey-headed Flying-fox. The project proposal was also strongly supported by the NSW Flying-fox Consultative Committee.

The project commenced in October 2006 and focuses on commercial crops in the western Sydney Basin. To date (May 2007), preliminary evaluations have been conducted, including total yield loss, damaged fruit (including that specifically attributable to flying-foxes and birds), flying-fox crop visitation indices and crop architecture. These parameters will be compared throughout the fruit season across different stone fruit and apple crop types and between netted and un-netted crops to examine spatial and temporal trends. The process of establishing and implementing the collaborative project is discussed, within the framework of flying-fox conservation and management in NSW.

Key words: *Pteropus poliocephalus*, conservation, management, fruit crop protection

Introduction

The Grey-headed Flying-fox (*Pteropus poliocephalus*) was listed as a vulnerable species under the NSW *Threatened Species Conservation Act 1995* on 4 May 2001. The species was further listed nationally as a vulnerable species on 4 December 2001 under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. The species is listed as threatened under the Victorian *Flora and Fauna Guarantee Act 1988* and its conservation status in Queensland is currently under consideration.

The Grey-headed Flying-fox is a canopy-feeding frugivore, blossom-eater and nectarivore of rainforests, open forests, woodland, Melaleuca swamps and Banksia woodlands (McWilliam 1986, NSW Scientific Committee 2001). Nectar and pollen from eucalypts, melaleucas and banksias are the primary food for the species (Parry-Jones 1987, Eby and Lunney 2002, Eby 1995). As such, the Grey-headed Flying-fox is a key species in maintaining forest ecosystems through the dispersal of rainforest seeds and pollination of native tree species (McWilliam 1986). The high mobility of the species (Spencer *et al.* 1991) enables it to spread pollen and seeds much further than would otherwise occur through abiotic vectors such as wind. The connectivity of isolated forest remnants and fragmented habitat is thereby facilitated through the movement of foraging flying-foxes.

The Grey-headed Flying-fox is unique in that while listed as a threatened species, it is also recognised as a horticultural pest, predominantly in the coastal orchards of south-eastern Australia (Fleming and Robinson 1987, Loebel and Sanewski 1987, Gough 2002). In times of

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native resource shortage, flying-foxes are known to utilise commercial fruit crops and the species is consequently affected by control techniques employed by horticulturists to mitigate flying-fox damage (Ullio 2002). The fruit industry considers flying-foxes to be the main vertebrate pest in coastal areas of NSW and south east Queensland (Jamieson 1987), with an average gross loss to the market value of fruit estimated at $10.4 million per year from 1995–2000 (Ullio 2002). While it is generally believed that flying-foxes prefer native food resources to commercial crops, horticulturists report otherwise.

NSW Flying-fox Consultative Committee

Following the NSW listing of the species as threatened, the then National Parks and Wildlife Service sponsored the Royal Zoological Society of NSW to host a forum "Managing the Grey-headed Flying-fox as a threatened species in NSW" in July 2001. At this forum, the National Parks and Wildlife Service announced the formation of the NSW Flying-fox Consultative Committee (Gilligan 2002). The formation of such a committee with representatives of all stakeholders received great support (e.g. Bower 2002). The NSW Flying-fox Consultative Committee held its inaugural meeting in August 2001. The Committee is an open forum of stakeholders whose membership currently comprises representatives from a mixture of government, non-government and community organisations: NSW Department of Environment and Climate Change, NSW Department of Primary Industries (Science and Research, and Agriculture and Fisheries divisions), NSW Farmers' Association (including two horticultural representatives), Local Government and Shires Association, BananasNSW, NSW Royal Society for the Prevention of Cruelty to Animals, the Nature Conservation Council of NSW, the scientific/research community, and the Australian Government Department of the Environment and Water Resources.

The Consultative Committee has been working together for six years, to openly discuss the issues and to determine the strategies for flying-fox conservation and management in NSW. In 2002, the Committee undertook an analysis of the knowledge gaps for Grey-headed Flying-foxes, and prepared a submission to the NSW Treasury seeking funding. Although the submission was unsuccessful, the process enabled the Committee to prioritise the areas of research for the species. From this analysis have come several student and consultant research projects, including an attitudinal survey (Ballard 2004), a decoy feeding trial (MacFarlane 2004), investigation into roost site characteristics (Peacock 2004) including microclimate (Eggleston 2005), a foraging habitat ranking and mapping project (Eby and Law 2008), and the Grey-headed Flying-foxes in Orchards collaborative project (the focus of this paper).

National Recovery Plan for the Grey-headed Flying-fox

NSW has taken the lead role to coordinate preparation of a national recovery plan for the Grey-headed Flying-fox to identify the actions necessary to stop the species' decline, and to support its recovery. Funding for the preparation of the plan has been provided by the Australian Government and has provided for the involvement of the range states of the species (Queensland, NSW, Victoria and the ACT). A national recovery team and a consultative group were established in the development of the draft plan. As at the time of writing, the draft National Recovery Plan is in the latter stages of finalisation, and will be publicly exhibited, providing an opportunity for interested parties to comment on the plan. Several recovery actions relevant to the identified threat of killing in commercial fruit crops are currently underway, through the Grey-headed Flying-foxes in Orchards collaborative project.

Conflict between Grey-headed Flying-foxes and orchardists

Extensive losses of native vegetation since the time of European settlement have greatly impacted Australia's native fauna, including flying-foxes (Birt 2000). The history of conflict between flying-foxes and fruit producers in Australia dates back to the early European settlers who introduced exotic fruits like apples, pears, citrus and stonefruit (Ullio 2002). The nature of this conflict continues to this day, and in the case of the Grey-headed Flying-fox, focuses on the coastal orchards of south-eastern Australia. While a variety of management techniques have been used by horticulturists over time to reduce flying-damage, shooting has been the most consistently used and widespread method (Waples 2002), either in the orchard as flying-foxes attack fruit, or at local camps (Hall and Richards 1987, Loebel and Sanewski 1987, Birt 2000).

Calls for research on methods to deter or prevent flying-fox damage to crops have been made by the horticultural industry and the research community for some time (e.g. Martin 1987), to remove from orchardists the financial burden imposed by the various crop damage mitigation techniques they implement (e.g. Bicknell 2002, Biel 2002, Comensoli 2002, Rogers 2002). Eby and Lunney (2002) argue that effective methods of on-crop control and conflict resolution at camps are essential to the recovery of Grey-headed Flying-foxes. Full exclusion netting is considered the only reliable means to avoid crop damage by flying-foxes (Fleming and Robinson 1987, Ullio 2002, Waples 2002), and the only humane method currently available (Gough 2002). Decreased natural habitat and resource availability to flying-foxes likely increases pressure on orchards, however poor financial returns for orchardists makes it hard for them to afford the cost of exclusion netting (Gough 2002).

The impact of culling on flying-fox populations remains a contentious issue even if it is not considered the major threatening process for the Grey-headed Flying-fox (Dickman and Fleming 2002). As cited by Dickman and Fleming (2002) the only published information on the rate of cull of Grey-headed Flying-foxes in NSW suggested that 70,000 flying-foxes were being shot each year in the early 1990's (Vardon and Tidemann 1995). Such practices of killing Grey-headed Flying-foxes in crops is carried out on the assumption that the species is

organised as discrete local populations whose size can be controlled locally (Eby and Lunney 2002). Negative attitudes towards flying-foxes, both from the horticultural industry and the general community, have also been assessed and documented (Lunney *et al.* 2002, Ballard 2004).

Horticulturists in the Sydney Basin continue to report (anecdotally) increasing levels of flying-fox crop damage in successive years (E. Biel pers. comm. 2006). A lack of scientifically defensible data on crop damage caused by flying-foxes has proven difficult when economic analyses and investigations into possible solutions to the flying-fox crop damage mitigation problem have been attempted in recent times.

The real impact of crop damage mitigation techniques on flying-fox numbers is unknown, and the effectiveness of such techniques in actually reducing crop damage has not been adequately evaluated. Inconsistent levels of crop damage between years (Fleming and Robinson 1987, Waples 2002), both on a temporal scale and on crop variety, and the cost of netting are reasons often cited by orchardists as to why they haven't installed full exclusion netting to prevent flying-fox damage (Ullio 2002, Biel 2002).

Grey-headed Flying-foxes in orchards – collaborative project

In December 2005, the Australian Government offered Natural Heritage Trust Strategic Reserve funding for the 2006–07 and 2007–08 financial years. The established partnerships within the NSW Flying-fox Consultative Committee facilitated a joint submission for funding by the then NSW Department of Environment and Conservation (now the Department of Environment and Climate Change) and the NSW Department of Primary Industries for a collaborative project to investigate flying-fox damage to commercial crops. Input on the proposal was specifically sought from the horticultural representatives in NSW Farmers' Association because orchardist involvement was critical to the project's success. The proposal was supported by the NSW Flying-fox Consultative Committee and deemed a priority research project. The proposal was submitted by the Hawkesbury–Nepean Catchment Management Authority, a partner in the project.

In May 2006, the application was successful and the project received $397,000 in Commonwealth Natural Heritage Trust funds. Approximately $450,000 in matching contributions was provided through in-kind and cash support from the NSW Government and the flying-fox stakeholders, and the project commenced in October 2006.

It is an ambitious project given the limited timeframe. However, the information sought is critical and timely, both to conserve the Grey-headed Flying-fox and to preserve the livelihoods of orchardists. The objectives of the project include:

- to obtain accurate estimates of Grey-headed Flying-fox damage to individual fruit crops and to determine relative abundance indices of flying-foxes within participating orchards. This will enable analysis of the relationship between Grey-headed Flying-fox density and crop damage;
- to describe and map the commercial fruit industries affected by Grey-headed Flying-foxes in coastal NSW, including the extent of netted and un-netted crops;
- to develop rapid and user-friendly, but accurate, methods to estimate damage – for use by horticulturists;
- to conduct economic analyses of existing and proposed flying-fox damage mitigation techniques;
- to determine in-orchard and external factors contributing to Grey-headed Flying-fox damage to crops (e.g. crop architecture, crop type and weather); and
- to assess the on-ground effectiveness of non-lethal damage mitigation techniques (e.g. netting and decoy feeding) and combinations of these.

The project currently focuses on orchards in the Sydney Basin.

Expected outputs of the project include:

- developing a better understanding of crop types that are impacted by Grey-headed Flying-foxes, the current control strategies (including netting) used and where they are located in NSW;
- the accurate measurement and mapping of crop damage within the orchards participating in the Sydney Basin project;
- developing rapid methods that orchardists can use to estimate crop damage, allowing longer term monitoring of crop damage. It is hoped that these methods can be applied across all areas affected by flying-fox damage;
- assessment of the effectiveness of non-lethal damage mitigation techniques (including netting and decoy feeding);
- economic analyses of existing and proposed flying-fox damage mitigation techniques (cost/benefit analyses). These analyses will address whether the cost of erecting exclusion netting is warranted given the loss mitigation it affords, and indicate the level of shooting effort that is required to reduce crop damage;
- improving our understanding of the contributing factors to Grey-headed Flying-fox incursions into crops, the crops affected and temporal changes in Grey-headed Flying-fox damage; and
- predictions of spatial and temporal distribution of Grey-headed Flying-fox incursions into orchards. It is hoped that the results of Eby and Law's (2008) mapping of Grey-headed Flying-fox foraging habitat can be used to determine whether there is a correlation between the predicted naturally available foraging habitat and flying-fox damage and whether there is a seasonal component to such damage trends.

This project implements several recovery actions from the draft National Recovery Plan for the Grey-headed Flying-fox which address the horticultural component of threats

to flying-fox conservation. As an overall output, the project seeks to provide soundly-based and well-costed strategies for horticulturists to use for flying-fox damage mitigation in commercial orchards, including non-lethal damage mitigation strategies.

A Project Steering Committee has been established to oversee the implementation of the project, with membership from the NSW Department of Environment and Climate Change, the NSW Department of Primary Industries, the Hawkesbury–Nepean Catchment Management Authority and Sydney Basin horticulturists. The Steering Committee established a protocol for communication between the parties of the project, and determined the requisite skills of the two Project Officers to undertake the research. The Steering Committee jointly developed media releases to promote the project, and its members have given various public presentations to promote the project. The Steering Committee met in May 2007 to monitor the project's progress and plan for future work. The timing of meetings accommodates the demands of the Sydney Basin 'growing season' to facilitate representation of the horticulturists.

The Project Officers appointed to the project are based at the NSW Department of Primary Industries' Richmond office, to facilitate easy access to the orchardists and their orchards. Thirteen orchardists from the Kurrajong, Glenorie, Bilpin and Southern Highlands areas are currently participating. Parameters under investigation to date include total yield loss, temporal and spatial fruit and tree damage (differentiating between flying-fox and bird damage), flying-fox crop visitation indices, and crop architecture. These parameters will be compared across different stone fruit and apple crop types, and between netted and un-netted crops to examine spatial and temporal trends.

Some preliminary observations (Ho Dang, Peter Malcolm, and Tom Bergin, unpublished data) include:

- there is tremendous variability in the levels of damage between orchards;
- it appears that the pressure of flying-fox damage on crops is not constant– the numbers of flying-foxes visiting an orchard and the associated levels of damage are highly variable and unpredictable;
- at the time of writing it is unclear whether the flying-foxes are favouring particular crops or whether that crop is simply the one that is available at that point in time; and
- consistent with previous reports by horticulturists, flying-foxes don't necessarily target ripe fruit.

Flying-foxes in the Bilpin area were observed taking commercial fruit back to flowering native windbreak/shelter trees. This highlights the need to investigate the quantity and quality of nectar and pollen available in flowering natives. Further investigation to determine whether a flowering native tree necessarily represents an adequate native food resource is suggested.

Tribulations

Frustration is often expressed at the pace of resolving the issues surrounding flying-fox conservation and management in NSW (e.g. Comensoli 2002). The complexities of Grey-headed Flying-fox conservation and management in NSW (and beyond) needs to be recognised, as does the subsequent time taken to progress such issues. There is a need for informed decision-making, however knowledge gaps remain and it will take time and money to fill these gaps. Limited resources are also a reality, though the state and national listing of the Grey-headed Flying-fox as threatened and the national approach to manage and conserve this species has seen an increase in the research being funded in recent years.

Flying-foxes generally have a pretty poor public image, as evidenced by Ballard's (2004) attitudinal survey of horticulturists and the general community. The Grey-headed Flying-fox often comes into conflict with humans at the urban interface.

The primary threat of habitat loss continues, putting extra pressure on the habitat that remains. The general community has a moral and social responsibility to conserve biodiversity, and this includes the Grey-headed Flying-fox. Increased temperatures and high humidity in the Sydney basin as a result of climate change is also likely to increase incursions of Grey-headed Flying-foxes into orchards and urban areas (Parris and Hazell 2005).The Grey-headed Flying-fox is a highly mobile species that moves around the environment in response to native resource availability (Eby 1991, Spencer *et al.* 1991). Changing the commonly held perception that their numbers are increasing remains a challenge. Furthermore, the count methodology that has been used to obtain information on the distribution of Grey-headed Flying-foxes and to estimate the size of the national population needs refining (Westcott and McKeown 2004), to facilitate monitoring of population trends for the species, and to improve the general acceptance of the methodology and subsequent results.

Orchardists find the timeframes of the project a tribulation; they require answers and solutions immediately to preserve their livelihoods. The reality, however, is that it takes time to collect robust, scientifically defensible data. In the Grey-headed Flying-foxes in Orchards project, the involvement of so many players necessarily extends the time required.

Collaboration requires agreement between multiple parties. The administrative processes are more complex, and there are various reporting requirements to ensure the project milestones are delivered on time.

Competing priorities always play a role, and the limited resources for the Grey-headed Flying-foxes in Orchards project govern what can realistically be achieved in the given timeframe. The recruitment of the two Project Officers took time, as did the development of the experimental methods. Staffing logistics have also been a challenge, as much of the work happens after dusk when the flying-foxes are foraging. This research is costly in terms of labour.

The project was submitted to the Commonwealth as a three-year project, but funding through this particular program was being offered for two years only. The Project Steering Committee is seeking additional funding to facilitate further data collection to capture the damage variation that occurs between years.

Triumphs

And now to focus on the positives – the triumphs – and there have been many. The continuation of the NSW Flying-fox Consultative Committee is an achievement, given the often disparate views of members, and the ongoing challenges to progress the issues surrounding flying-foxes. The personal commitment of individual members, their respect and appreciation of the spectrum of views and issues relating to flying-fox conservation and management is laudable. The Committee's analysis of knowledge gaps has led to several research projects being funded, and the submission of other applications for funding.

The recovery planning process has provided an opportunity for a collaborative and consistent approach by the State and Commonwealth government agencies across the species' range. The Recovery Plan documents the recovery actions for the species, facilitating implementation by relevant parties. The funding and implementation of several recovery actions to date has been a triumph, even before the plan is finalised.

The collaborative nature of the Grey-headed Flying-foxes in Orchards project has been an achievement in itself. The project partners include the NSW Department of Environment and Climate Change and the NSW Department of Primary Industries, the Hawkesbury–Nepean Catchment Management Authority, the NSW Flying-fox Consultative Committee and the Commonwealth Government. This is a collaborative project on several levels, giving the project increased credibility, kudos and support. Collaboration has helped to remove the 'sides' to the problem; the stakeholders are working together to find a workable solution both for flying-fox conservation while preventing the decline of the horticultural industry in the Sydney Basin.

The participation of growers in the Grey-headed Flying-foxes in Orchards project has been another major triumph. The NSW Department of Environment and Climate Change and the NSW Department of Primary Industries are grateful to the growers for their good will towards the project – without them the project could not proceed. To date there have been no rejections from growers approached to participate in the project. This is largely because we've been able to build on the existing relationships developed by the NSW Department of Primary Industries' District Horticulturists at Richmond and Camden. The formation of the Project Steering Committee has also been a triumph. It acts as a sounding-board for project activities, and as a conduit for information dissemination relating to the project and on flying-fox issues more broadly.

The Grey-headed Flying-foxes in Orchards project provides the foundation for ongoing work, and the research group will be applying for additional funds, both to continue the current objectives to collect adequate amounts of data over a sufficient timeframe and to broaden the objectives to undertake complementary research.

Conclusions

A detailed understanding of the economics of losses to orchardists caused by Grey-headed Flying-foxes and the cost–benefit analyses of damage mitigation methods and strategies are essential for the conservation of fruit crops and the animals. While collaboration may not always be the simplest process or the only option, we believe it increases the chance of success in the longer term. When multiple parties have responsibility for a particular matter, their active involvement is more likely to lead to multiple ownership of the problem and the solutions. Collaborative projects foster open communication between the various partners and facilitate an appreciation of the broader spectrum of issues. Involvement is the key – the process is not just informing people about the Grey-headed Flying-foxes in Orchards project results, but directly involving them in the project itself. Maintaining effective communication is critical in collaborative projects and is essential to maintaining goodwill – essential to any project really. However, expectations need to be managed in that they need to be realistic and are arguably influenced by previous experiences. We are confident of obtaining workable outcomes from the Grey-headed Flying-foxes in Orchards project through successful collaboration.

Addendum

The draft national recovery plan for the Grey-headed Flying-fox (DECCW 2009) was publicly exhibited for comment September 2009 – January 2010.

An additional $119,000 was provided by the Australian Government to extend the research period for the project and incorporate data from an additional fruit-growing season.

The Grey-headed Flying-foxes in Orchards collaborative project concluded in early 2009. The results are intended to be published as scientific papers and a summary is provided below:

Orchards in the Sydney Basin are spread across four main districts (Glenorie, Bilpin, Kurrajong and the Southern Highlands) that together produce 10,000 tonnes of mostly stone fruit and apples annually. This is 3% of NSW fruit production and 0.6% of Australian fruit production. Approximately 460 ha of land in the Sydney Basin is planted with commercial fruit crops, averaging approximately 8 ha per orchard.

Analysis of faecal material collected in early 2008 at three flying-fox camps within flying distance of Sydney Basin orchards suggests Grey-headed Flying-foxes prefer native food sources over commercial crops. Pollen and nectar from native trees accounted for 90% of the material identified in the faeces. Orchard fruit material was detected in <5% of faecal samples.

Despite their native food preferences, incursions of even a small number of flying-foxes in a commercial orchard can substantially decrease fruit yield. Exclusion netting experiments, development of a rapid assessment methodology to estimate damage levels and a grower survey were used to determine flying-fox impacts on Sydney Basin orchards.

The survey of 27 growers indicated that crop yield, crop yield loss and gross profit were independent of the actual area under crop. Average crop yield loss was 37% (7–100% in any one year) comprising flying-fox, bird and physiological (e.g. fruit splitting, sun bleaching and fungal spoilage) damage. Of this, 42% (11–83%) of total yield loss was attributed to flying-fox damage. When total yield loss exceeded 45%, flying-fox damage was proportionally lower.

From the start of the season, fruit load declined by 5% each week up until the week before harvest when up to 37% of the remaining fruit could be lost. Overall, initial fruit load loss (from all causes) was up to 60%.

Indicative numbers for harvestable crop yields for netted crops increased by 52% for apple trees and 20% for nectarine trees when compared to un-netted crops. That is, for an initial fruit load of 100 fruits, full-exclusion netting saved 20 apples and 8 nectarines. Such crop yield increases will vary with fruit type and variety, with the age and size of the trees, and with the orchard's pruning regime.

Twelve of the 27 growers surveyed had installed permanent, full-exclusion netting, covering approximately 30% of the total 296 ha of their orchards. Although only two growers had netted their entire crop, eight of the 12 growers had netted the majority of their crops. Growers with netted crops estimated netting costs (purchase and installation) as $15,000 – $75,000/ha (average $40,483/ha, s.e. = $5,624). Both the gross and unit area profit was independent of the proportion of crops under nets.

Modelling estimated the minimum installation cost of full-exclusion netting for all orchards in the Sydney Basin at $8.69 million (using the lowest cost estimate of $27,000 /ha). This total cost exceeds the total gross annual return of $8.5 million. The cost of full-exclusion netting for individual orchards is estimated at $27,000 – $648,000 per orchard.

Yield gains from netted crops in the 2007/08 season were 18% – 59% for apple orchards and 15% – 19% for peaches, consistent with grower estimates from their sales records. Average values obscure grower concerns in that yield losses vary between years, orchards, and between fruit type and variety. Determining the real effect of flying-fox incursions was difficult because there was no significant correlation between the index measuring flying-fox presence in orchards and yield loss as determined from experimental enclosures.

Of the available flying-fox damage mitigation methods, surveyed growers deemed netting and lethal means (i.e. shooting) as the only effective methods. Shooting was viewed as less effective than nets, however many growers relied on this method in the absence of netting. Shooting was used mainly to scare flying-foxes – only 4% of shots taken resulted in a kill over the 2007/08 fruit-growing season. However, the possible welfare implications of a large number of shots without kills should be considered.

All surveyed growers believed nets were the most effective means of controlling flying-fox incursions into orchards, however noted the costs associated with netting are substantial. Returns from such an investment are long-term and were considered to be increasingly hard to justify in a fickle market where the cost of finance and product sales prices are volatile. Many growers relied on the lower capital outlay option of shooting, despite this method being regarded as less efficient than netting. Overall, growers had reservations about government-backed loans for the installation of netting – they would prefer to pay for netting installation and receive compensation payments for projected crop losses when netting is not installed.

The abundance of foraging flying-foxes is difficult to measure given that foraging is widely spaced and patchy, and varies in local intensity between nights, orchards, and years and within any fruit-growing season. Night surveys in orchards during the 2006/07, 2007/08 and 2008/09 fruit-growing seasons detected flying-fox presence in two out of three observation nights. Rates of <50 flying-fox entrances into an orchard /hour (termed "incidence") were observed 70% of the time, and <20 incidences accounted for 50% of the observations. Although most observations were of relatively low flying-fox incidences, four major incursions were observed in 2006/07 (307, 367, 500 and 974 incidences), once in 2007/08 (300 incidences) and once in 2008/09 (161 incidences). This demonstrates that, although flying-foxes are capable of aggregating in an orchard, these events are infrequent and unpredictable.

Although flying-foxes ate fruit within orchards, foraging bats usually gathered fruit from orchard trees at the edges of orchard blocks, close to larger trees external to the orchard or in windbreaks, where they retreated to consume the fruit. Average numbers of flying-foxes foraging in orchards varied over time: between years, within fruit-growing seasons and nightly. Numbers also varied spatially among fruit-growing districts, among orchards, among blocks within an orchard, and among trees within an orchard block. Variability in damage and numbers of flying-foxes visiting orchards prevented the determination of flying-fox density /damage or flying-fox density /yield functions for either stonefruit or apple crops.

The project concluded that flying-fox foraging in orchards is irregular in space, time and intensity, making risk management a challenge for growers. At the time, growers considered 2006/07 to be a medium damage season, and 2007/08 and 2008/09 to be low damage seasons. Within seasons, damage can be substantial to individual trees, to orchard blocks, and to the yield and profitability of an orchard business. This project was not of sufficient duration to determine average yearly yield losses or patterns of damage between years.

Orchards are isolated pockets of high-quality food that flying-foxes use on occasion as needs determine, or simply through opportunity.

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