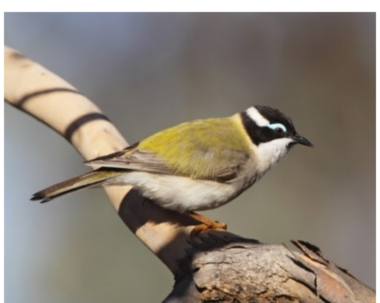
A Case for the GER: Conserving Functional Landscapes for Nomadic Pollinators

Peggy Eby + many, many others



Photos: V. Jones, Museum Victoria, T. Hayashi, Birdlife Aust

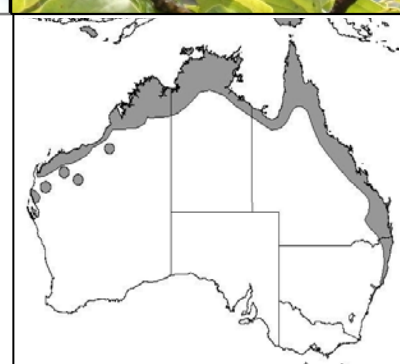
Migratory pollinators provide unique ecosystem services

- disperse pollen over large areas,
- link fragmented habitats,
- increase genetic variation in plants and plant populations,
- promote resilience and enhance capacity to adapt to change






Flying foxes of SE Australia

Grey-headed Flying fox *P. poliocephalus*	Black Flying fox *P.alecto*	Little Red Flying fox *P. scapulatus*
		
		

Diet of fleshy fruits, nectar and pollen






Blossom diet:
54 species of native trees (24% of eucalypts in their range)

Native fruit diet:
51 species of rainforest trees

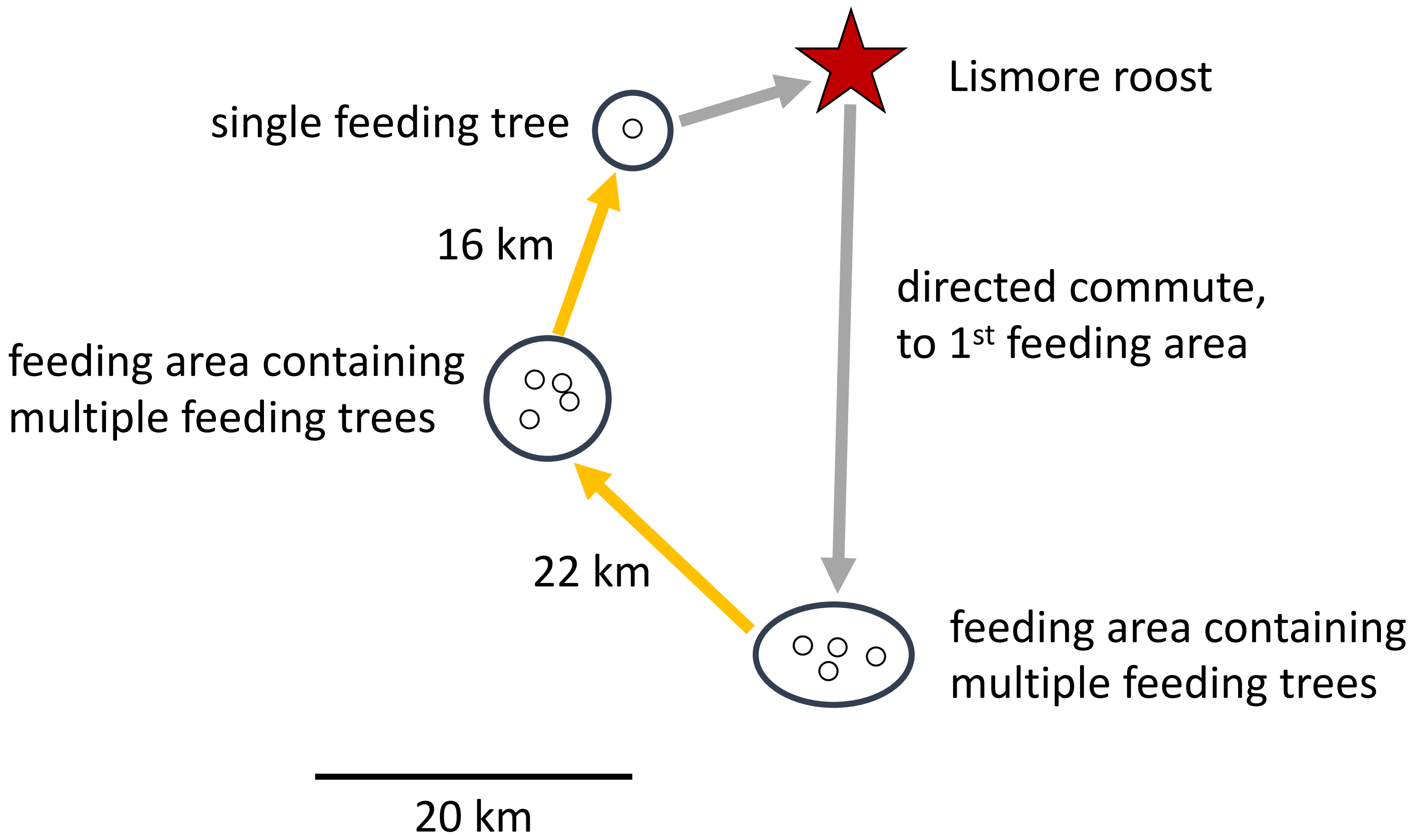
+ introduced species (growing list, increasing use)

Eby and Law (2008)

Pollination services are provided to a range of native trees

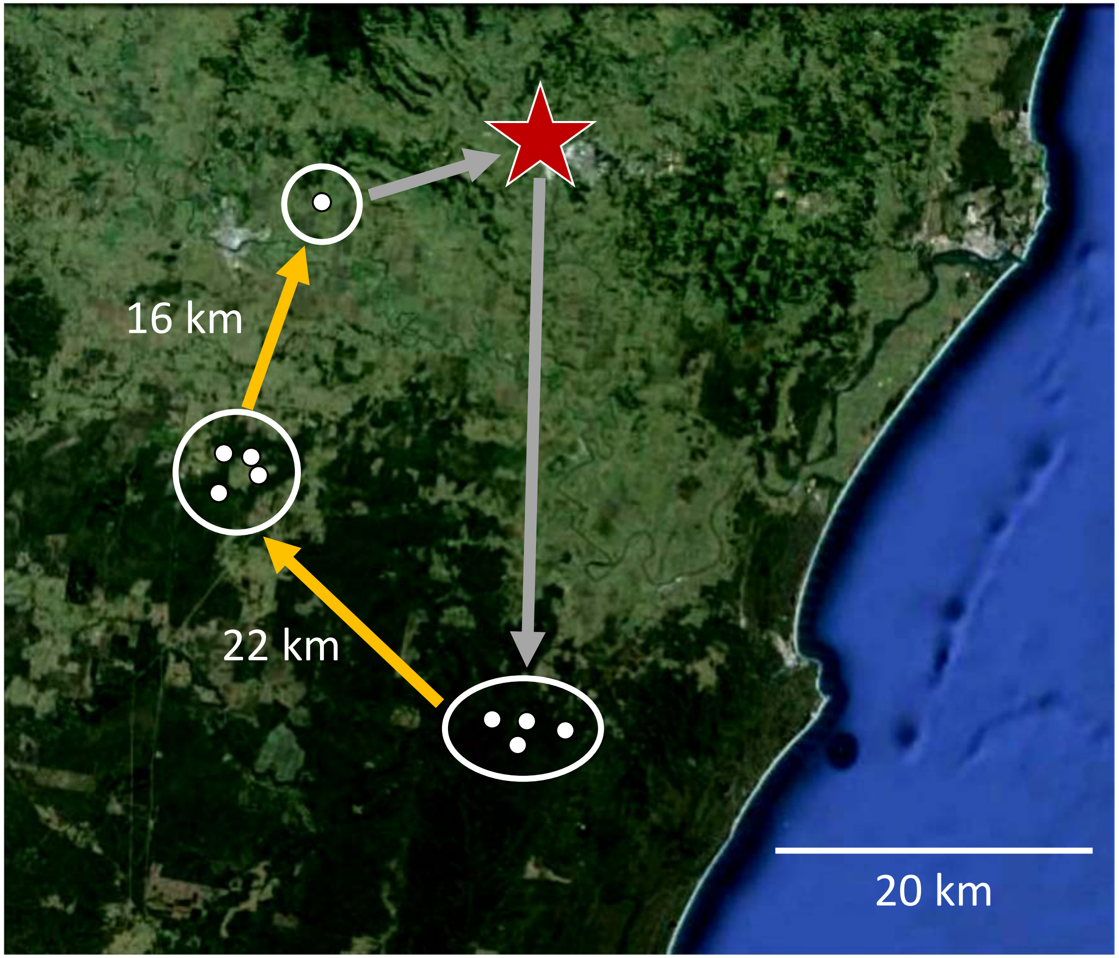
Nectar-fuelled foraging movements support pollen transfer over exceptionally long distances

(GHFF radio-telemetry - February 1989)



Eby (1991)

… genetically linking habitat fragments including isolated paddock trees



>30,000 flying foxes feeding on this resource were, collectively, distributing pollen in complex patterns across the fragmented habitat.

Overnight movements between roosts increase the distances pollen is transported

(GPS telemetry 17 July 2018)

M. Kessler, MSU, unpublished data

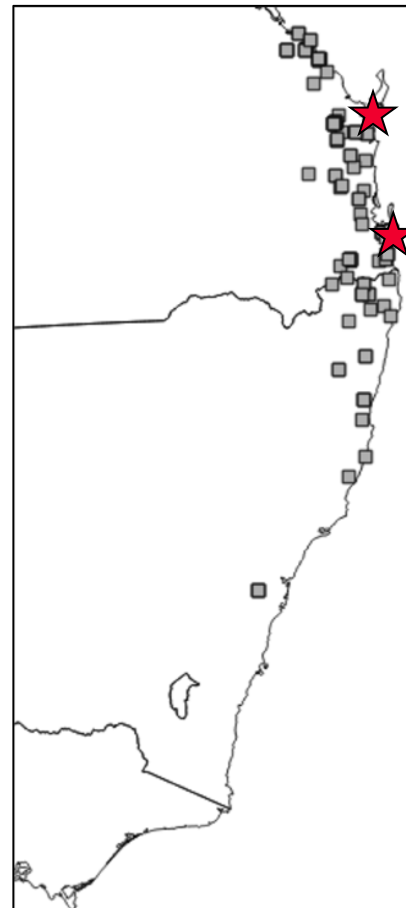
Flying foxes track ephemeral, largely unpredictable nectar pulses over long distances

a. radio-telemetry
summer to winter (n= 37)

Pink Bloodwood
Red Bloodwood
Spotted Gum
White Box
Sydney Blue Gum
Swamp Mahogany
Forest Red Gum
Paperbark
Coastal Banksia
Turpentine
various rainforest fruits

Eby (1991 & 1996)

b. satellite telemetry
winter to spring (n=17)



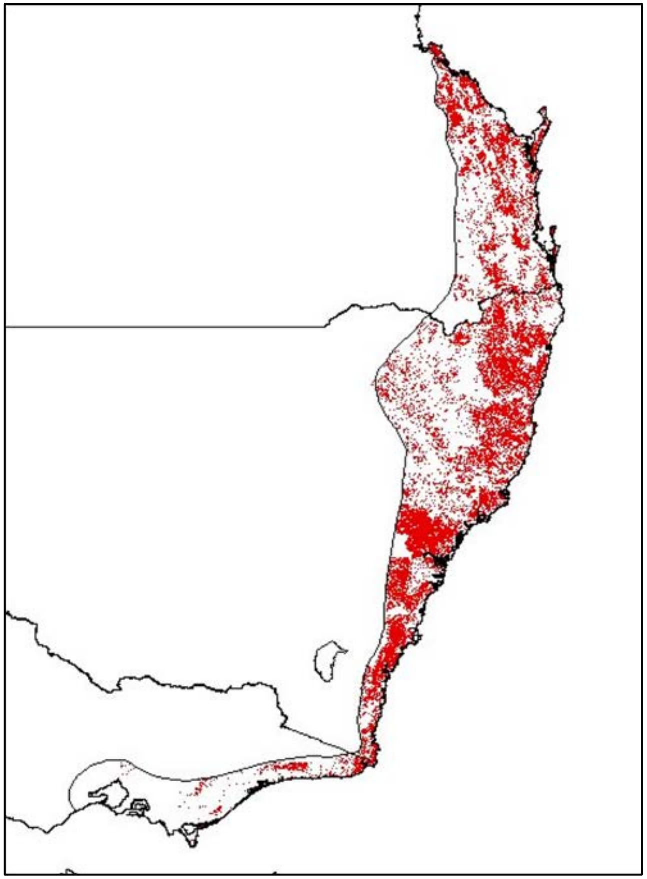
Lemon-scented Gum
Nthn Spotted Gum
White Box
Yellow Box
Blackbutt
Sthn Grey Gum
Forest Red Gum
Silky Oak
Turpentine

Roberts *et al.* (2012)

Nomadic nectar-dependent species are challenging to conserve

Evidence: seasonal bottleneck

Distribution of potential native feeding habitat in range of GHFFs (presence of diet plants in mapped remnant vegetation)



54 species of flowering trees in diet

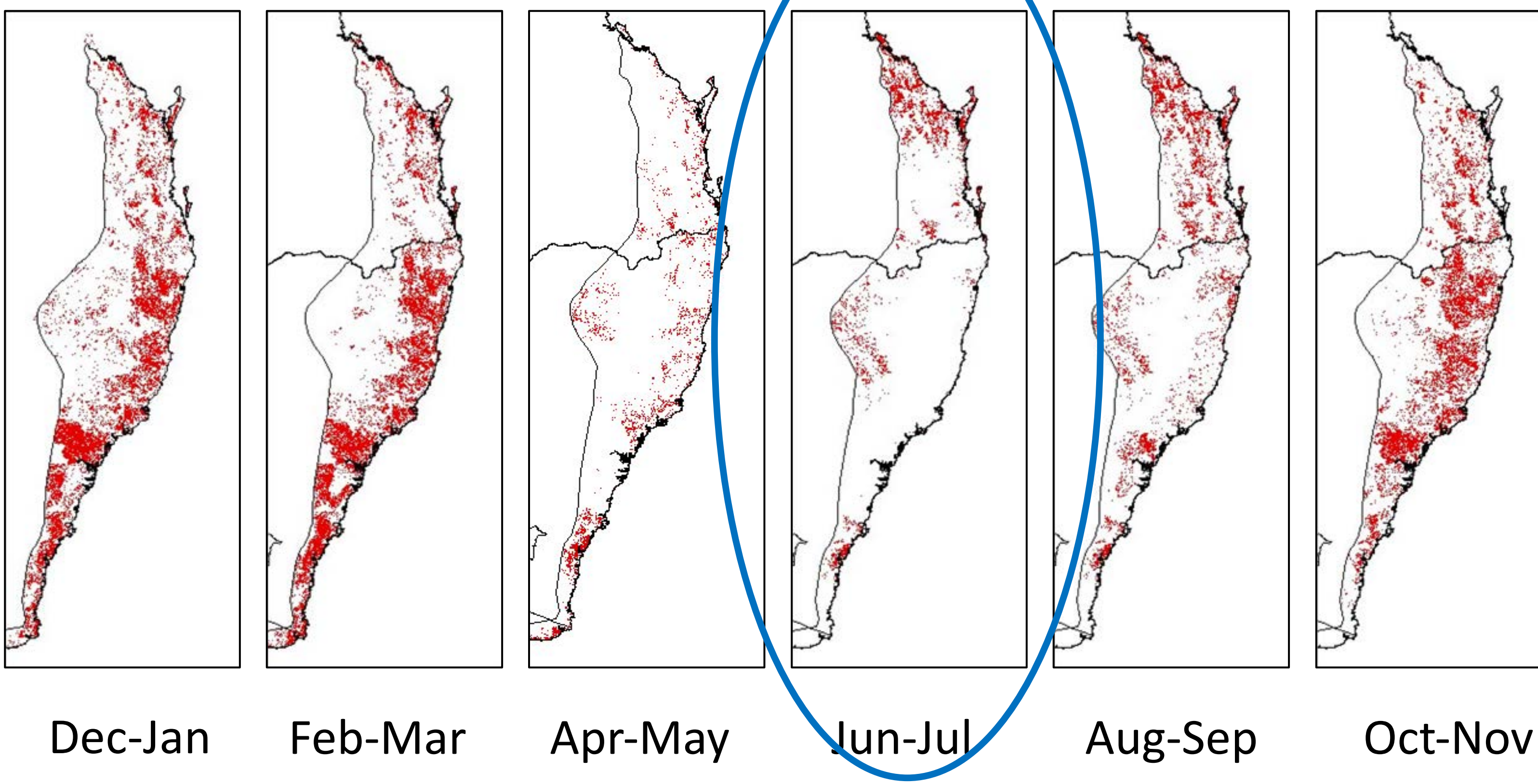
34% of land area contains feeding habitat (presence of diet species)

64% of extant remnant vegetation provides feeding habitat

Eby and Law (2008)

Evidence: seasonal bottleneck

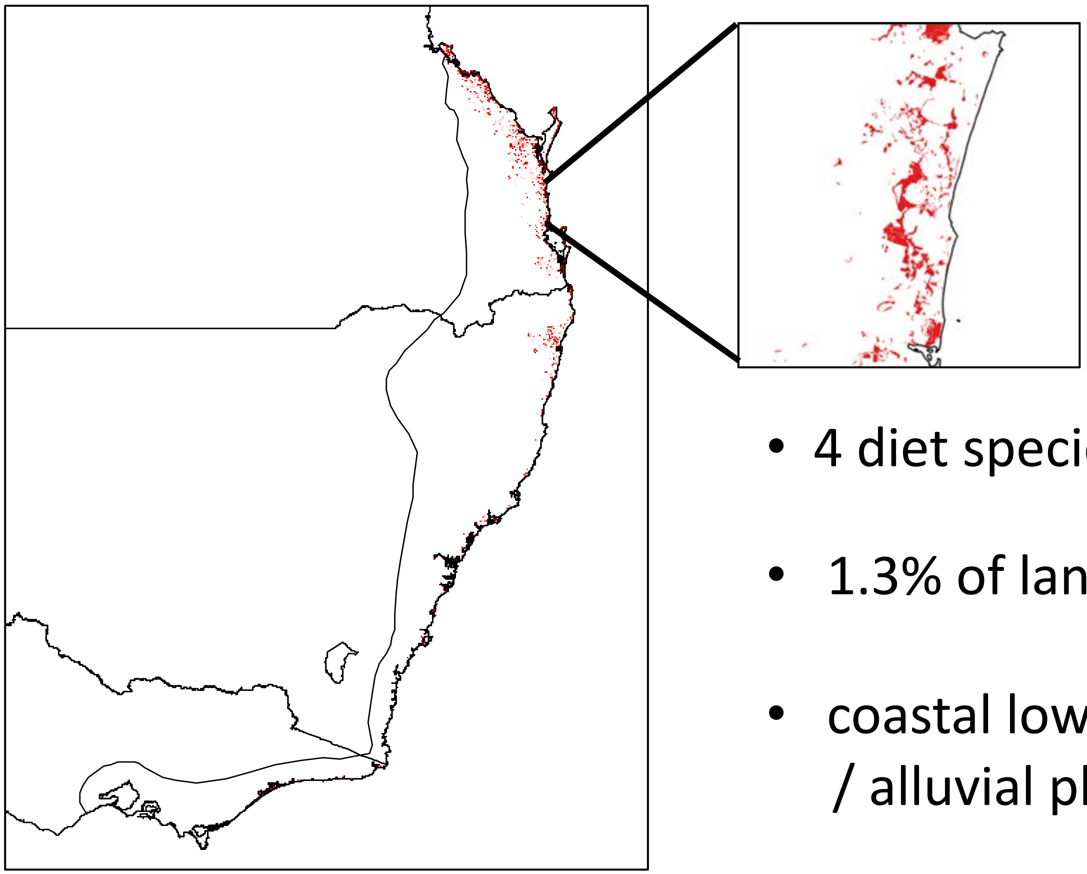
Distribution of potential feeding habitat at bi-monthly intervals



	Dec-Jan	Feb-Mar	Apr-May	Jun-Jul	Aug-Sep	Oct-Nov
species (n)	40	32	13	13	12	27
% land area	25%	24%	8%	8%	14%	22%
% extant veg	54%	51%	15%	18%	30%	46%

Evidence: limited reliable winter habitat

Distribution of June-July habitat productive in >33% of years



Polygon size:

mean 10.6 ha

median 3.4 ha

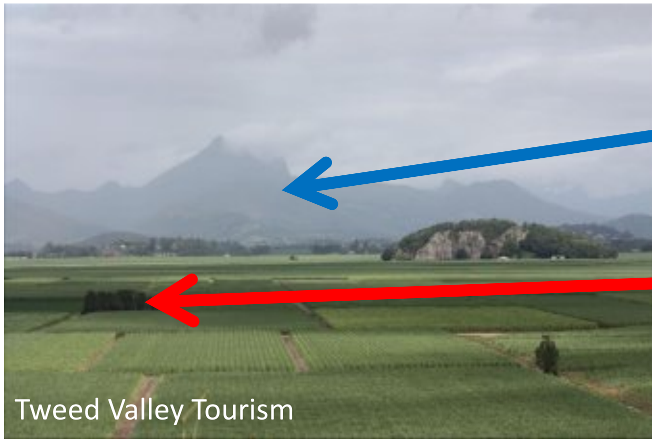
- 4 diet species
- 1.3% of land area
- coastal lowlands / floodplains / alluvial plains
- subject to largely unregulated incremental loss

Eby and Law (2008)

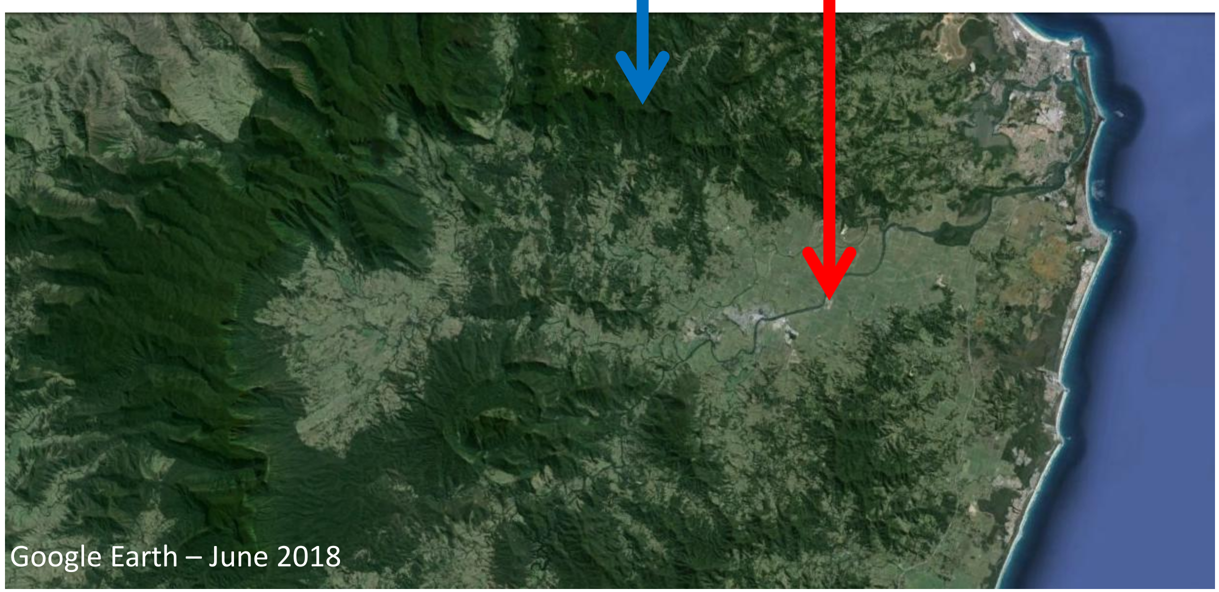
Disproportionate clearing of winter habitat for agriculture

Gondwanan Rainforest World Heritage Area
(summer / autumn feeding habitat)

Coastal floodplain EECs
(reliable winter feeding habitat)



Tweed Valley Tourism



Google Earth – June 2018

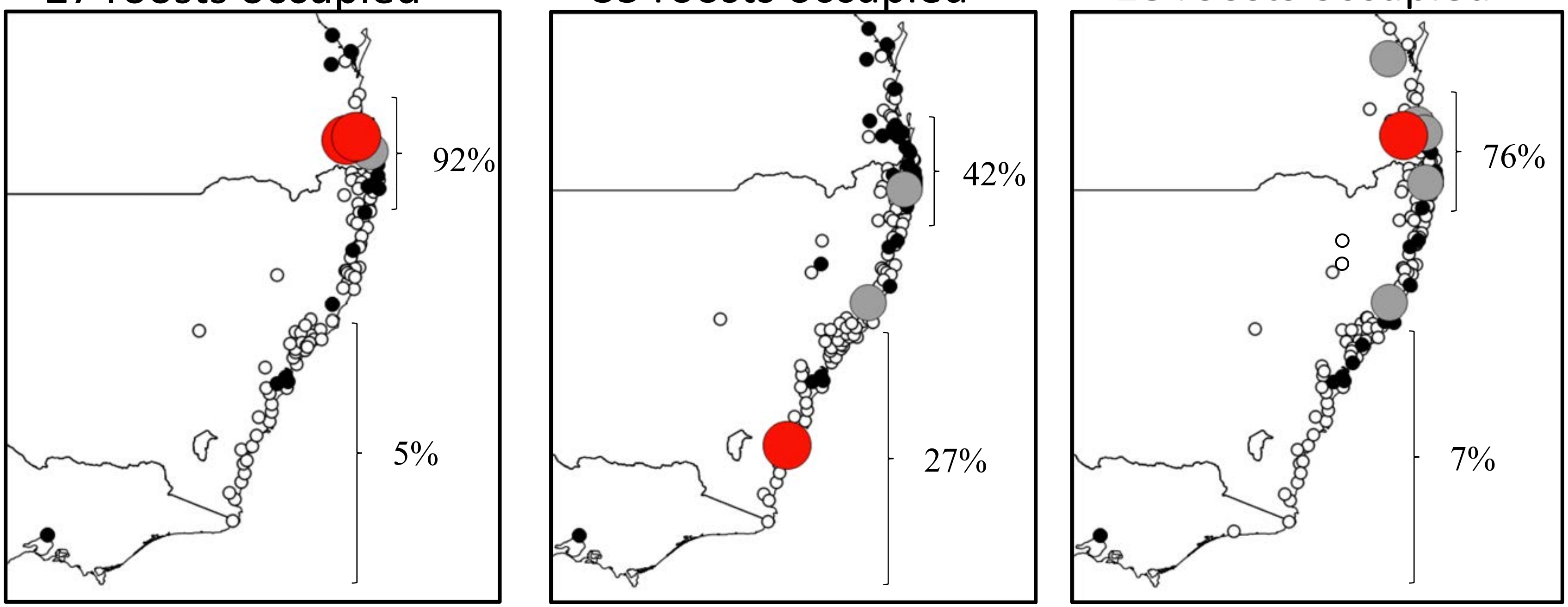
… and development

Evidence: the population concentrates in winter

The distribution of Grey-headed flying foxes in July 1998, 2001 & 2002.

○ = unoccupied; ● <30,000; ≥30,000; ≥75,000.

July 1998 — 27 roosts occupied | July 2001 — 35 roosts occupied | July 2002 — 28 roosts occupied

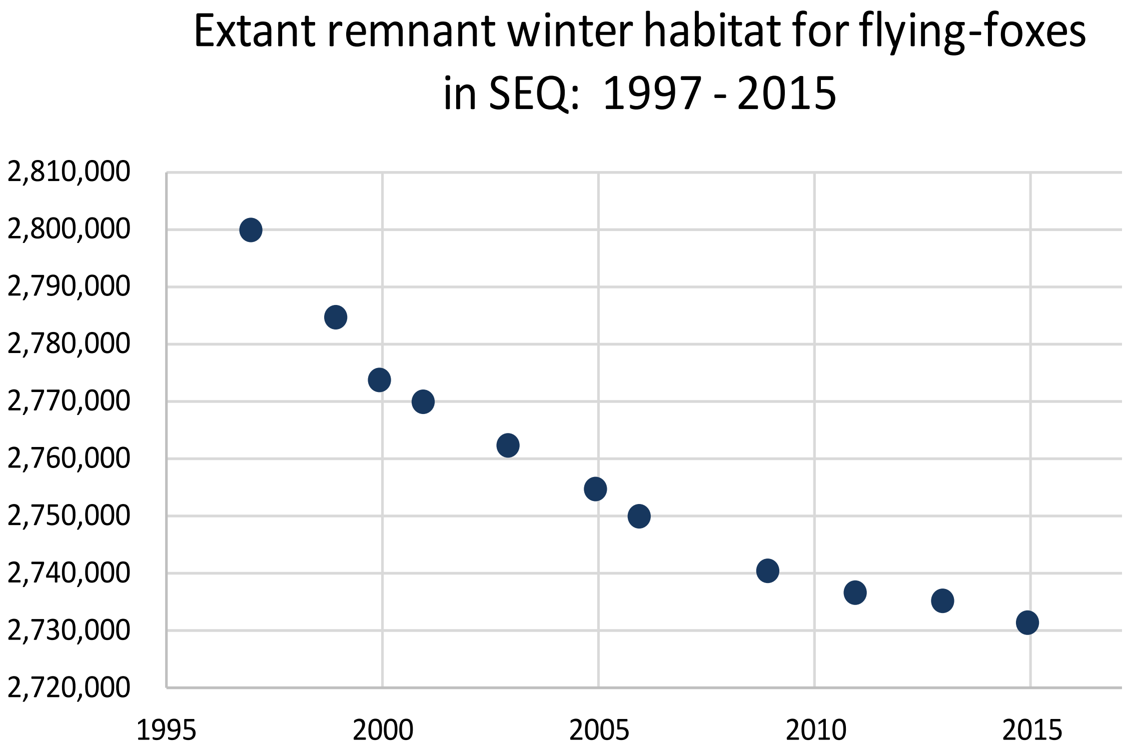


406,000 | 415,000 | 365,000

Eby et al (1999), Eby (2002)

Evidence: ongoing loss of winter foraging habitat in SEQ

70,000 ha of remnant winter habitat cleared in 20 yrs (RE mapping)
+ current work to determine pattern of loss in key areas

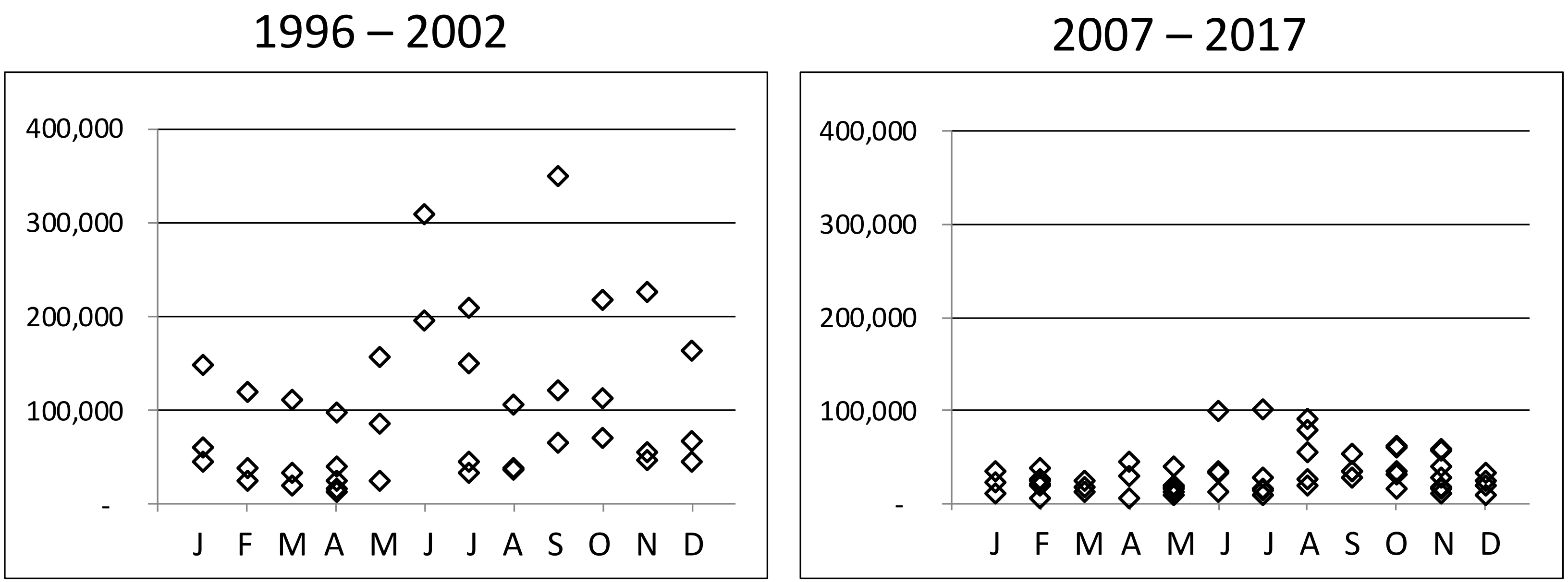


Qld Herbarium (2017)

Evidence: decline in population in far SEQ

monthly population estimates of Grey-headed flying foxes
combined counts - Brisbane + Ipswich + Gold Coast roosts

change is stable



no evidence of change in Black flying foxes *P. alecto*

Birt (2004); Eby (2004); DEHP unpublished (2017)

GHFF no longer concentrate in winter in far SEQ

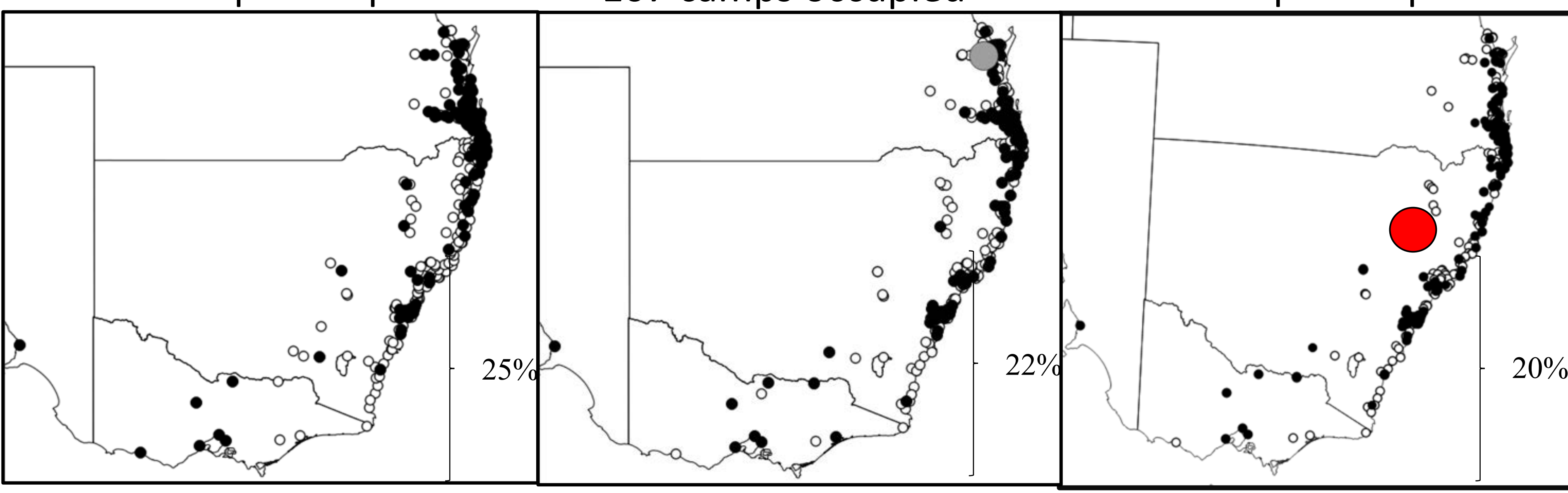
The distribution of Grey-headed flying foxes in August 2013, 2014, 2017.

○ = unoccupied; ● <30,000; ≥30,000; ≥75,000.

August 2013
125 camps occupied

August 2014
107 camps occupied

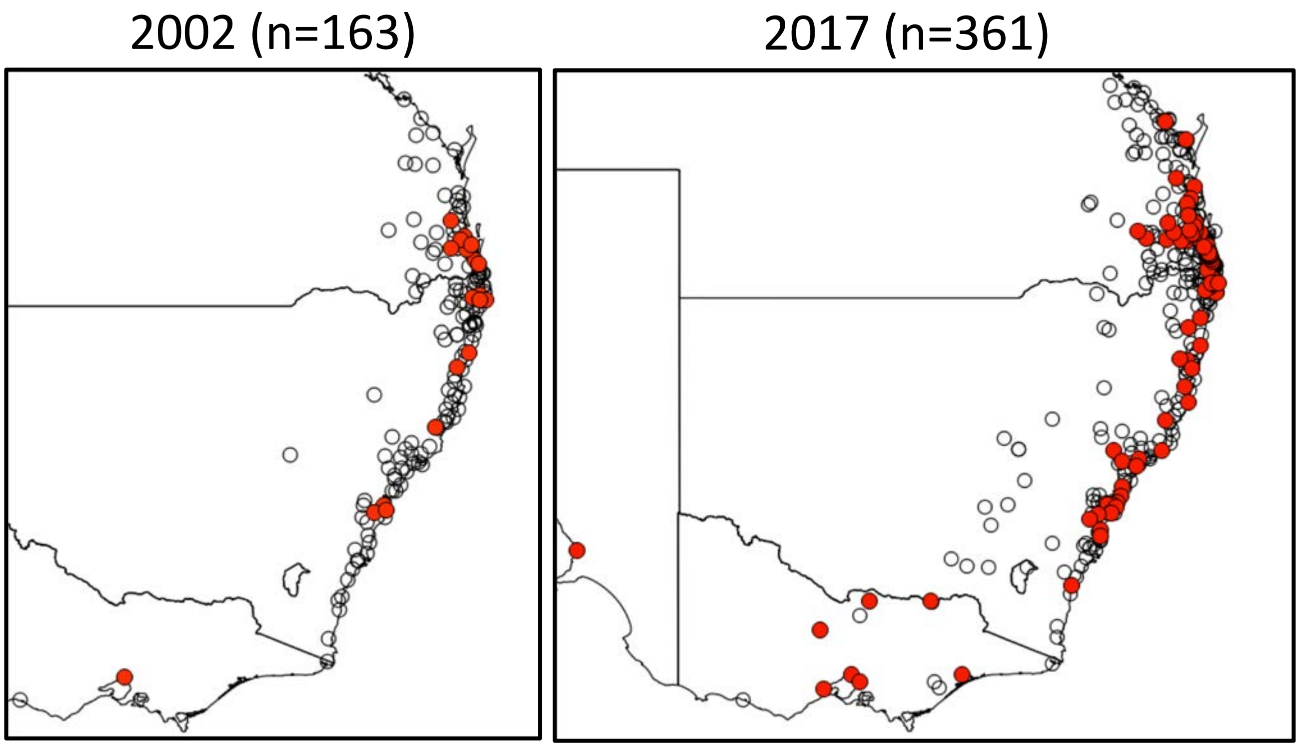
August 2017
75 camps occupied



CSIRO National Flying Fox Monitoring Program; http://www.environment.gov.au/webgis-framework/apps/ffc-wide/ffc-wide.jsf

Change in the number and distribution of roosts

Locations of active roosts of Grey-headed flying foxes

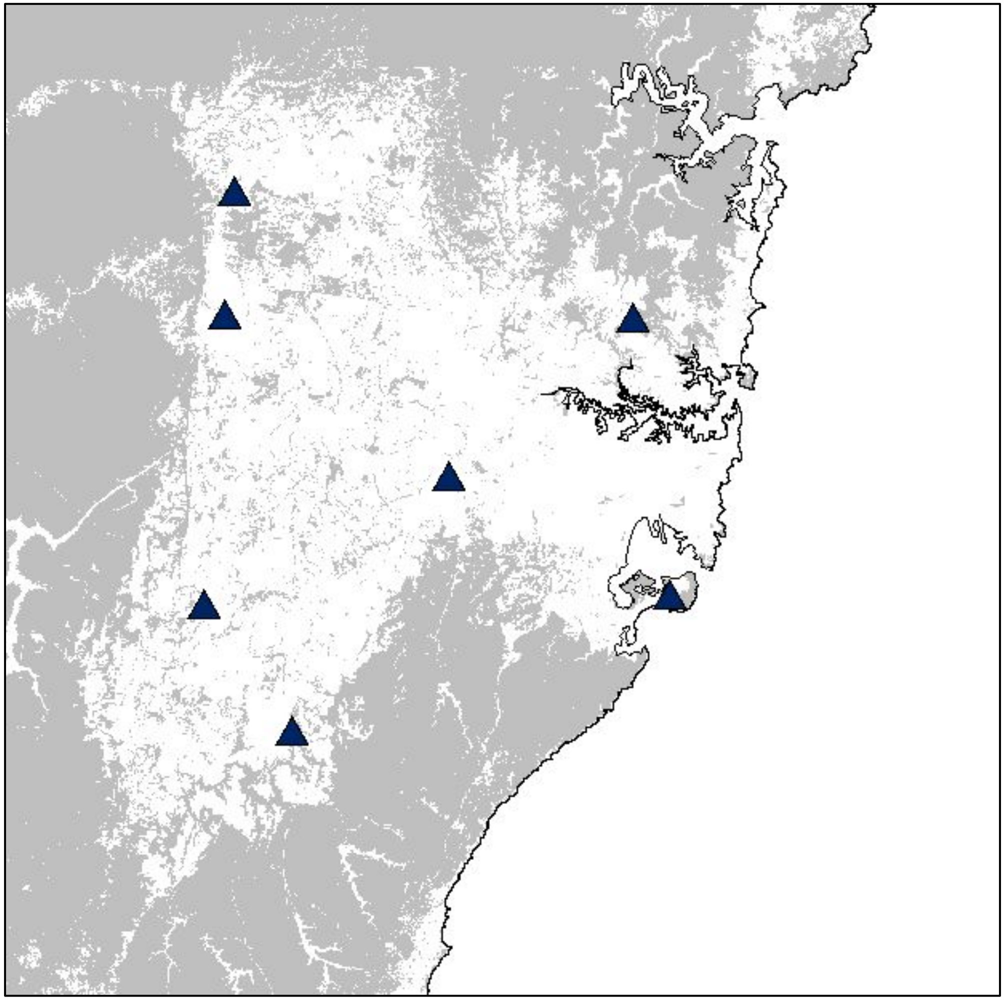


1. inland range shift
2. expansion in area of continuous presence (over-wintering)
3. increased density of roost sites
4. new roosts form near residential areas

Eby (2003); Qld DEHP (unpublished 2017); NSW OEH (unpublished 2017); Vic DELWP (unpublished 2017)

Increased density of roost sites

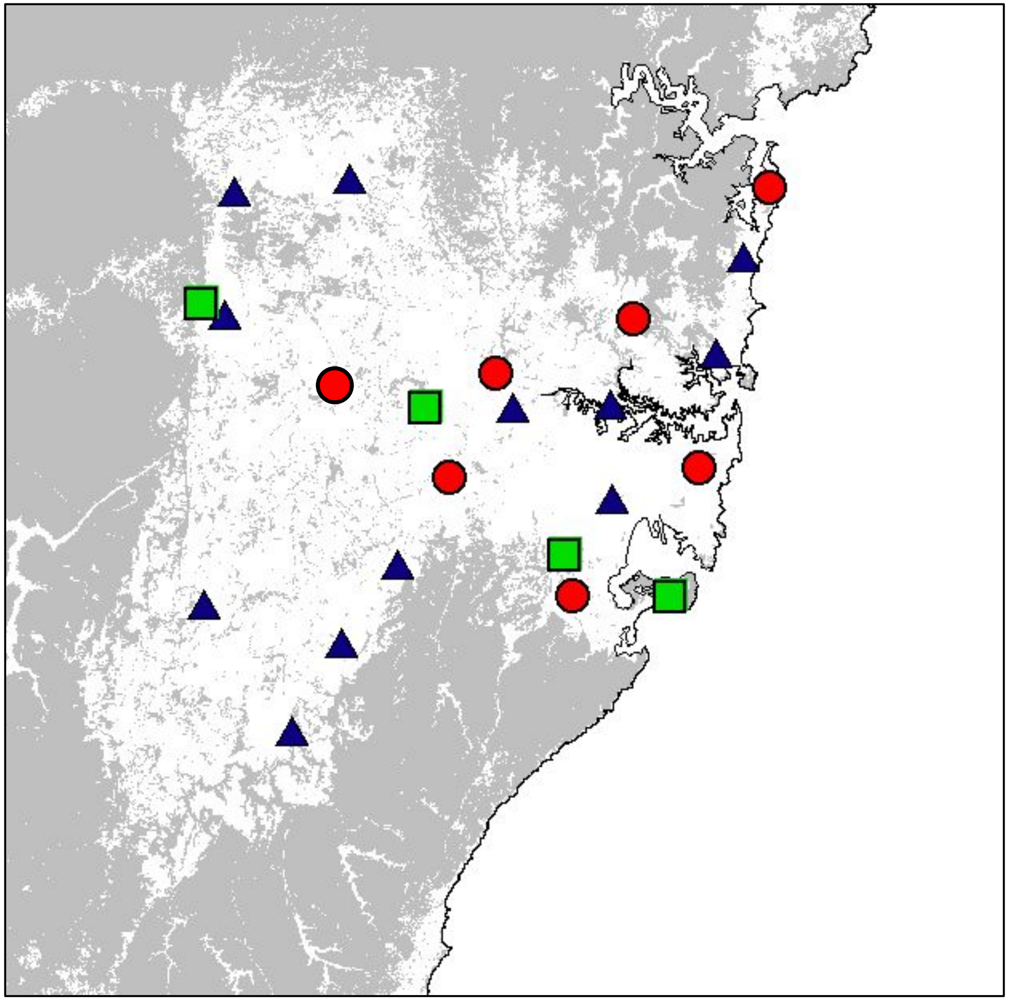
Sydney roosts 1988 (n=7)



▲ seasonal occupation

Increased density of roost sites

Sydney roosts 2017 (n=24)

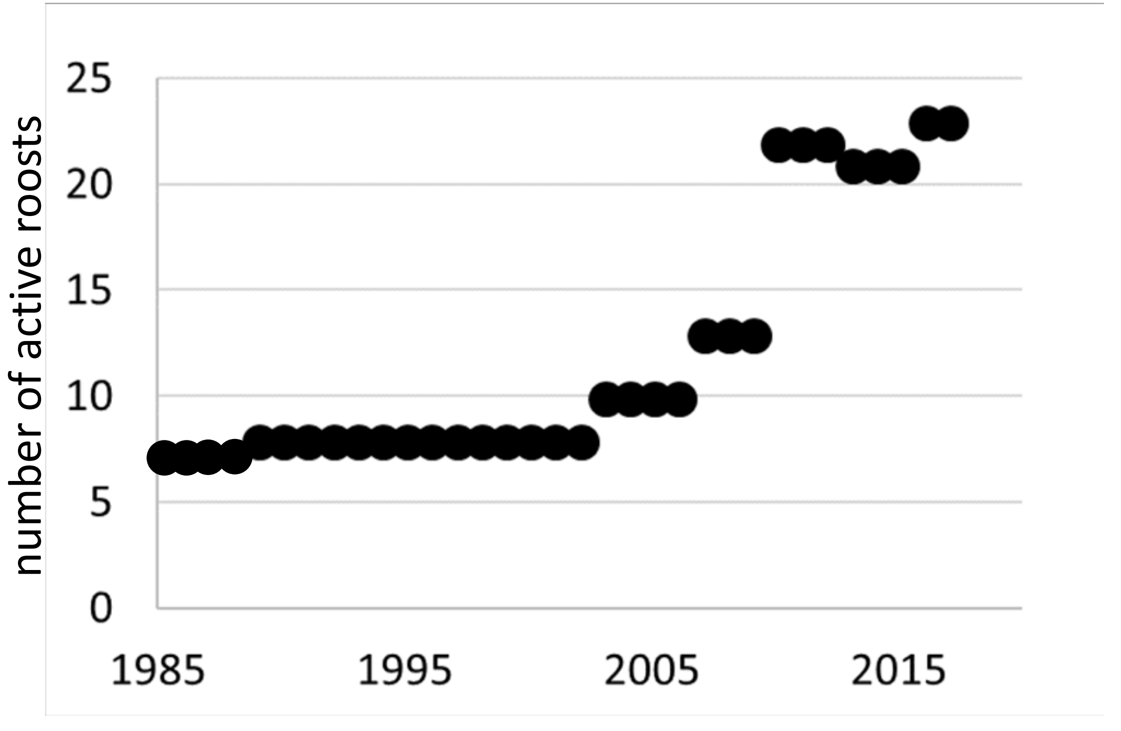


continuous seasonal irregular

Stepped pattern of increase

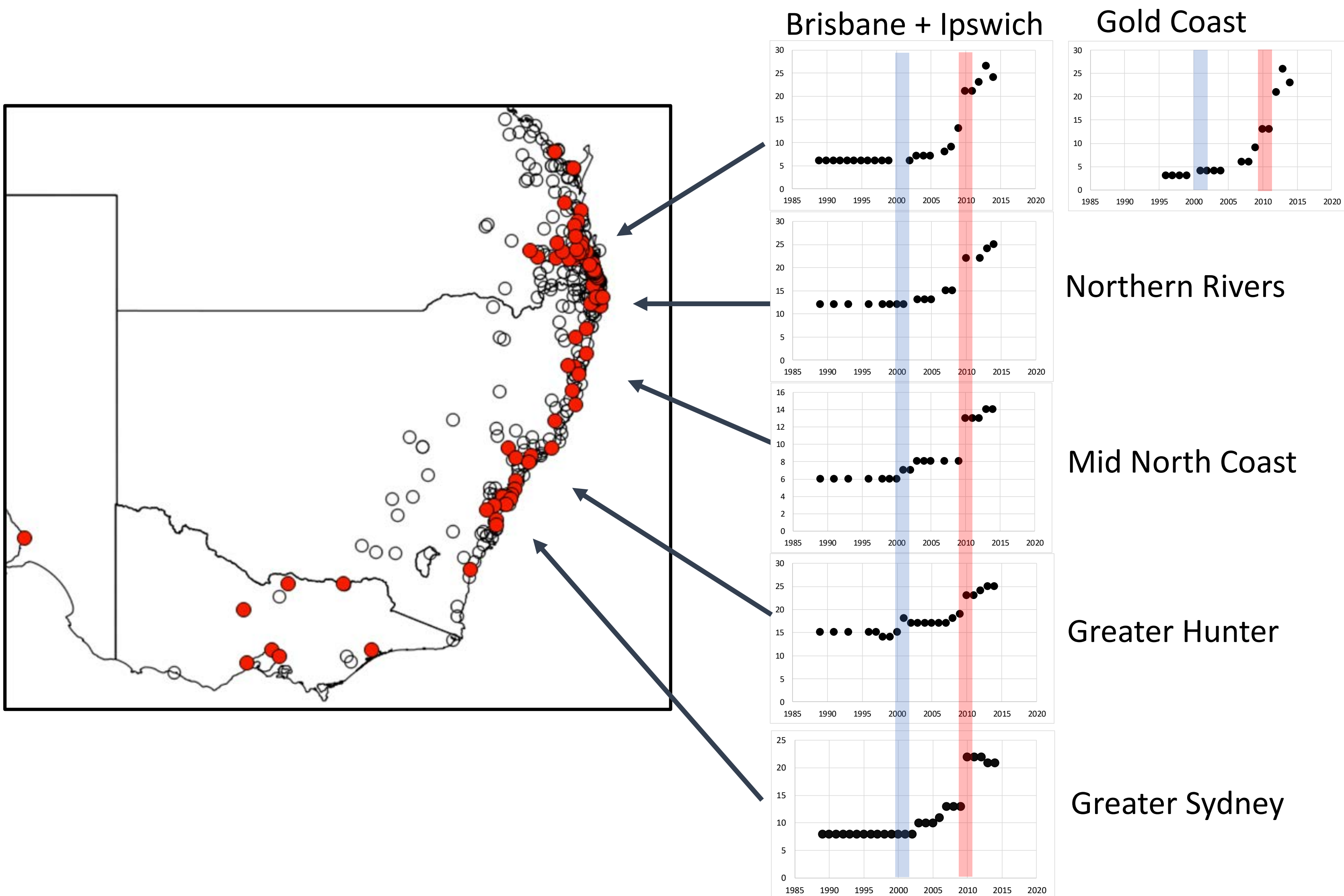
change in state from stable network to rapid increase

number of active flying fox roosts in Greater Sydney: 1989-2017



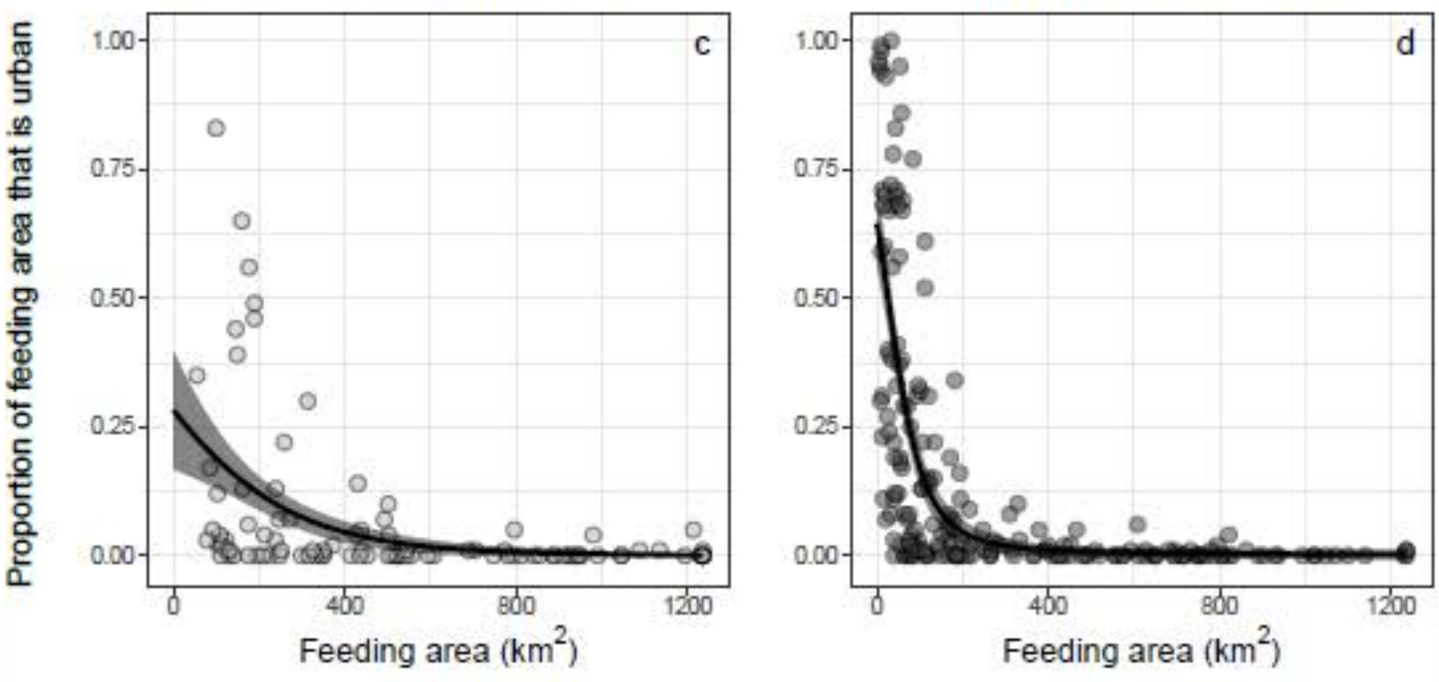
The pattern of change has been consistent between regions

Counts of active roosts 1989 - 2015



Eby (2003); DEHP (2015); CSIRO www.environment.gov.au/webgis-framework/apps/ffc-wide/ffc-wide.jsf

Size of feeding areas has decreased;
Access to urban plantings and introduced food has increased;
Use of native feeding habitats has decreased

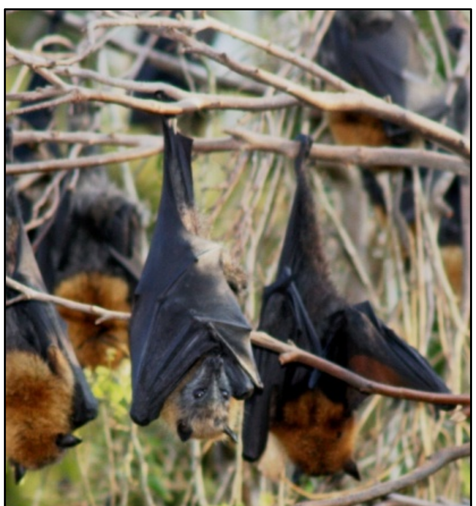


1998

2011

We’re losing long-distance pollination services

These behaviours are consistent with adaptive responses of flying-foxes to acute food shortages



Acute food shortages for flying foxes in south-east Australia

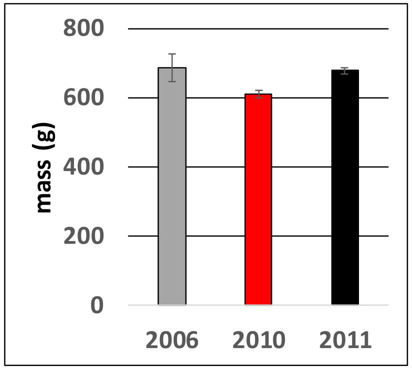
not uncommon – 12 in past 34 years

align with winter / spring bottleneck

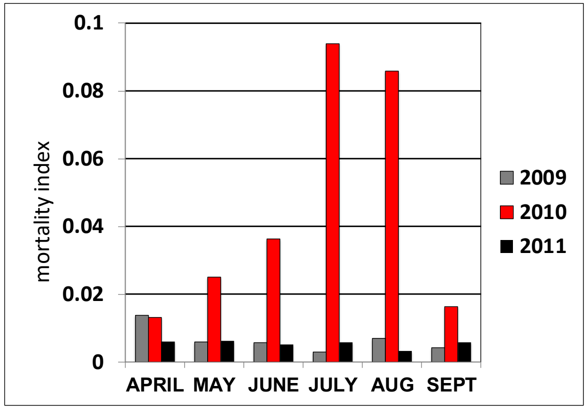
associated with gap in flowering in key plants

driver = temperature / rainfall

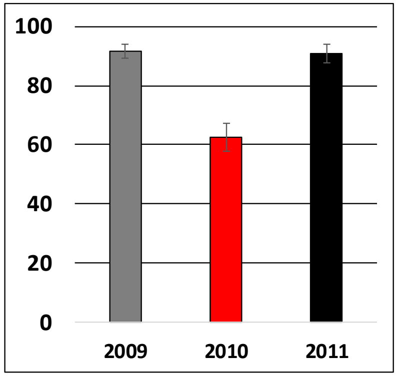
Markers of acute food shortages: population parameters



reduced adult body mass;

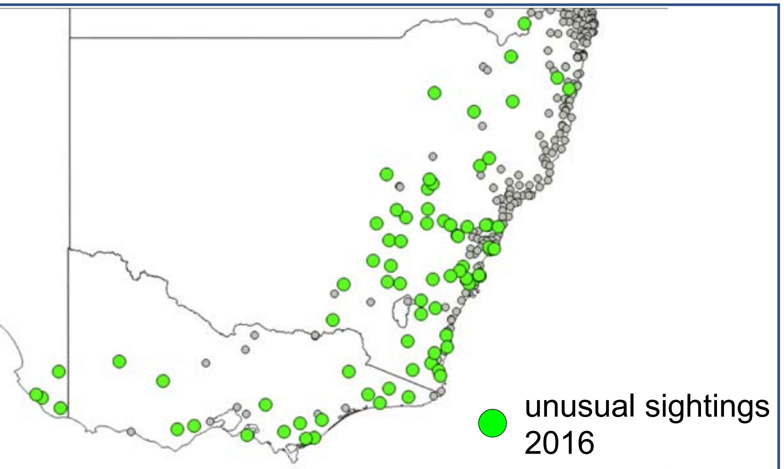


increased encounters by animal rehabilitation groups (index of adult mortality);



reduced reproduction (% females with young pre-weaning)

Markers of acute food shortages: predictable, reversible behaviours



incursions into atypical (marginal?) habitats not associated with native food and over-winter

disperse into multiple, small roosting groups

reduce feeding commutes

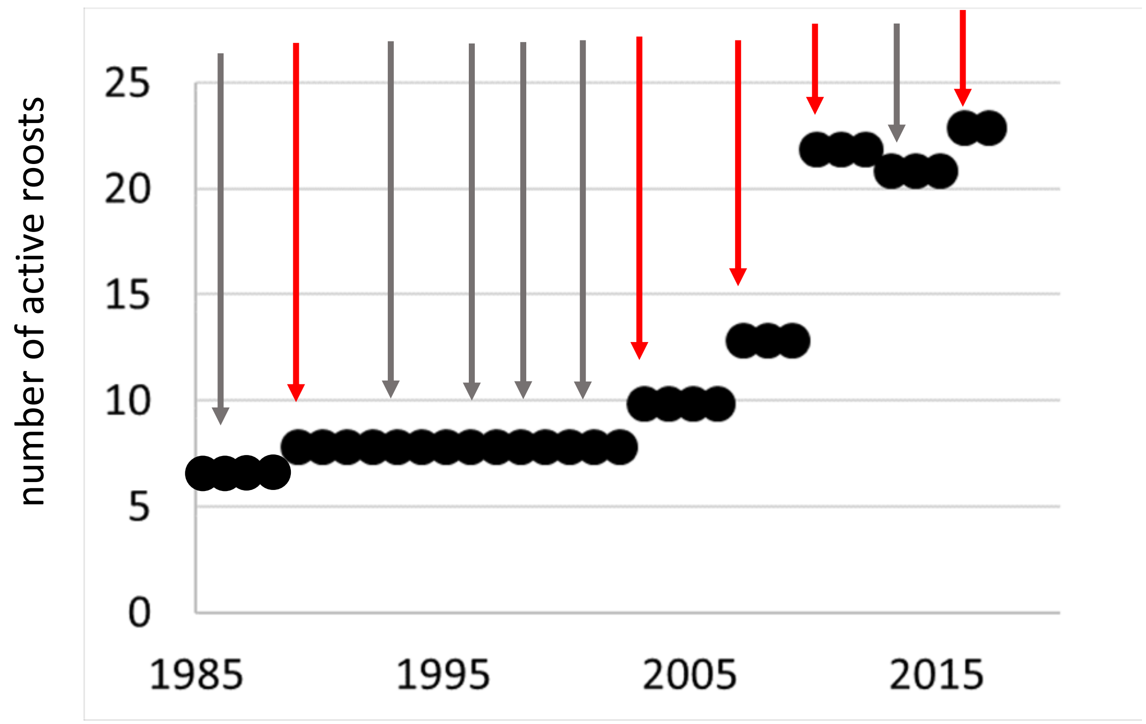
diet shift

++ low nutritional value?, secondary metabolites

++ introduced or cultivated food

New roosts in Greater Sydney establish during acute food shortages (arrows)

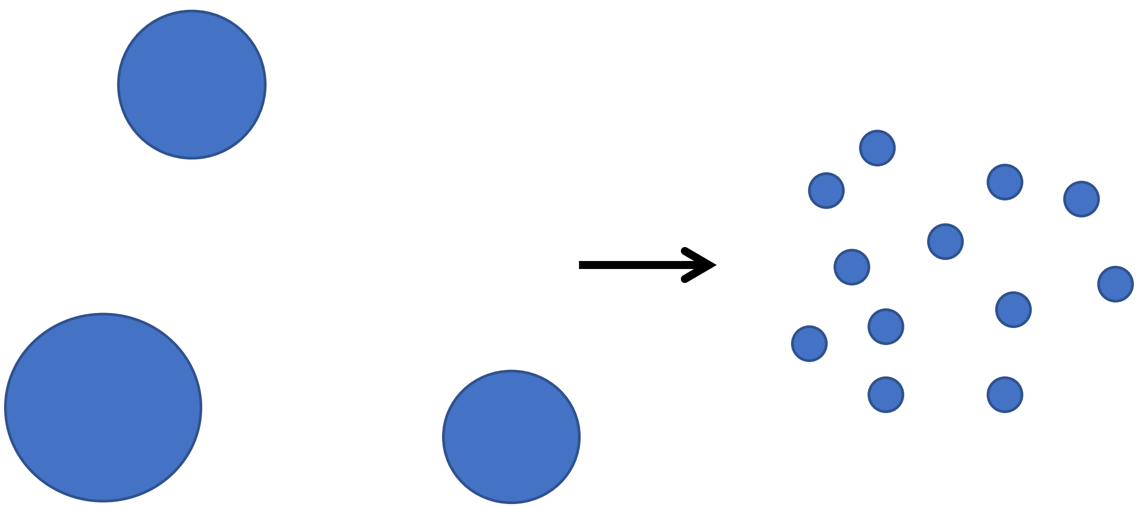
The positions of new roosts is set during food scarcity



Eby (2003 and 2007); Smith (2007); Eby *et al.* unpublished

Why more roosts?
Increased density reduces the energetic cost of foraging

New roosts form in locations that provide access to non-native, marginal, ‘starvation avoidance’ food)



We are ill-equipped to deal with this

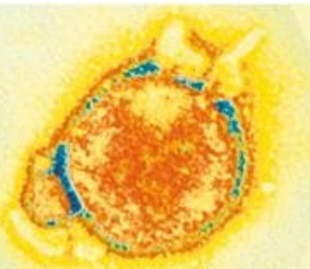
NSW bat plague: firefighters extinguish suspicious blaze at Cessnock bat camp

Sydney Morning Herald, May 23, 2016

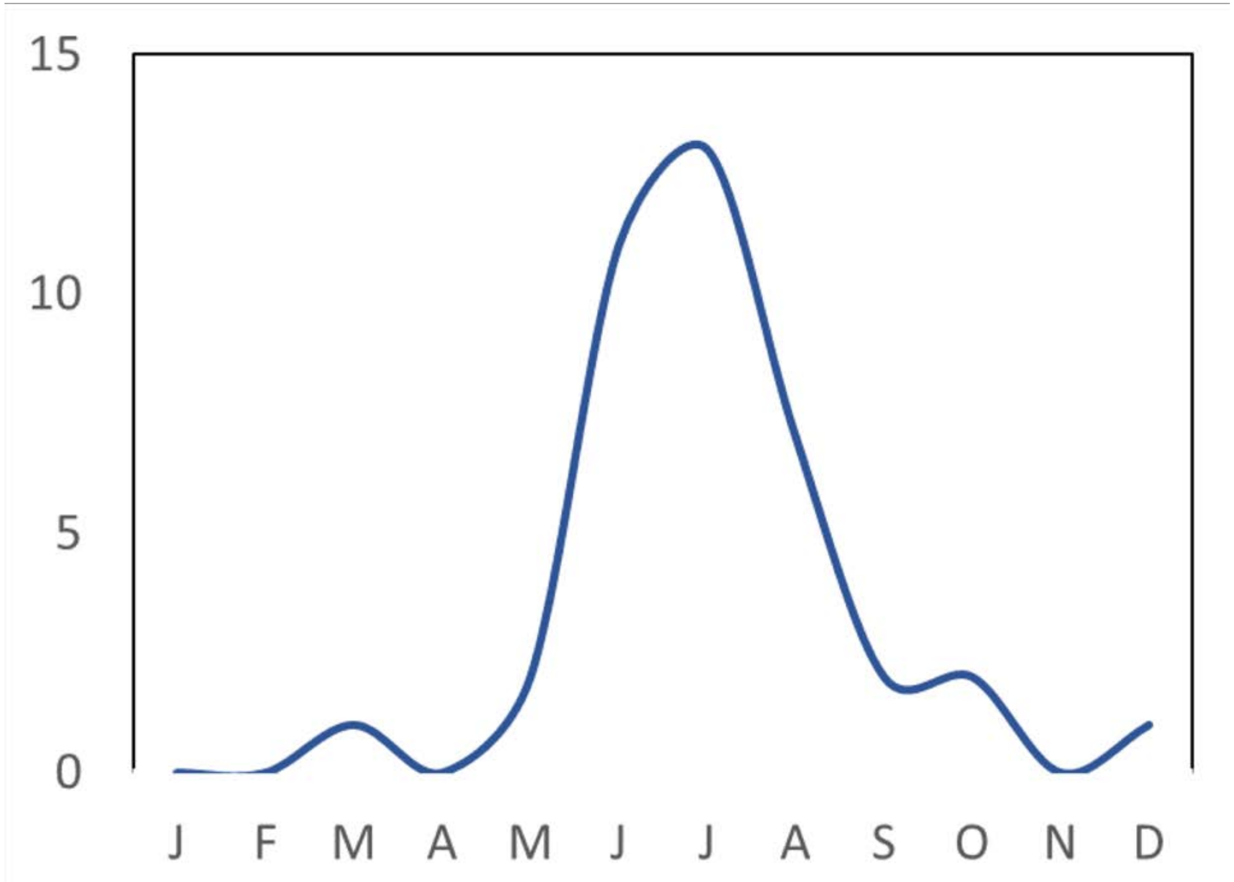
Alan Jones talks to the Environment Minister about cracking down on flying foxes

2/11/2014


Are there consequences for disease risk?



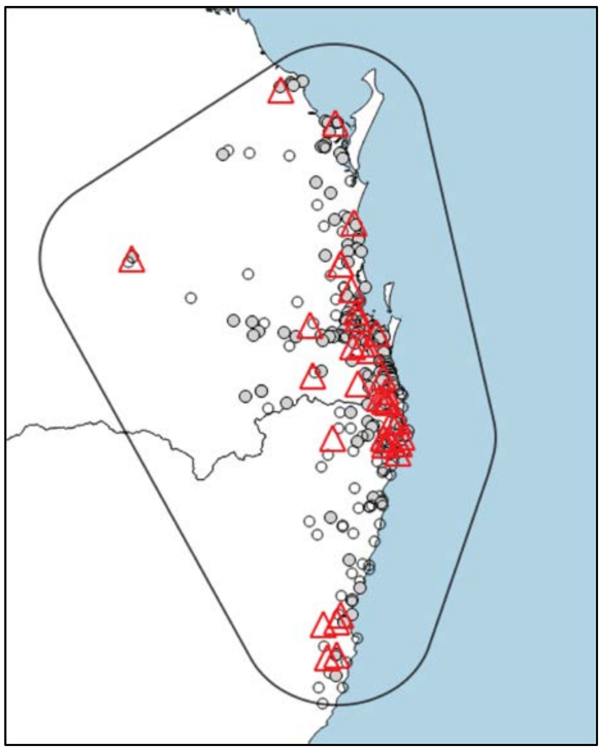
Hendra virus is largely a winter disease in subtropics

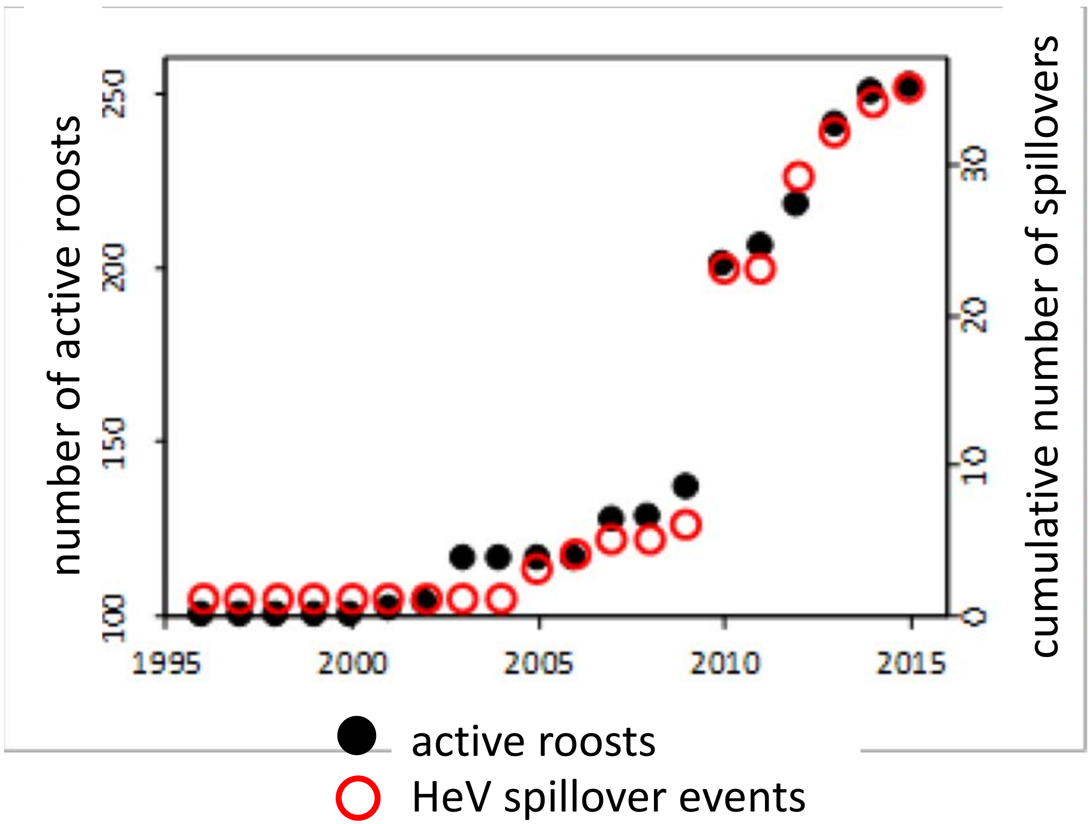


Hendra virus spillover subtropical Australia
1994-2017 n=39

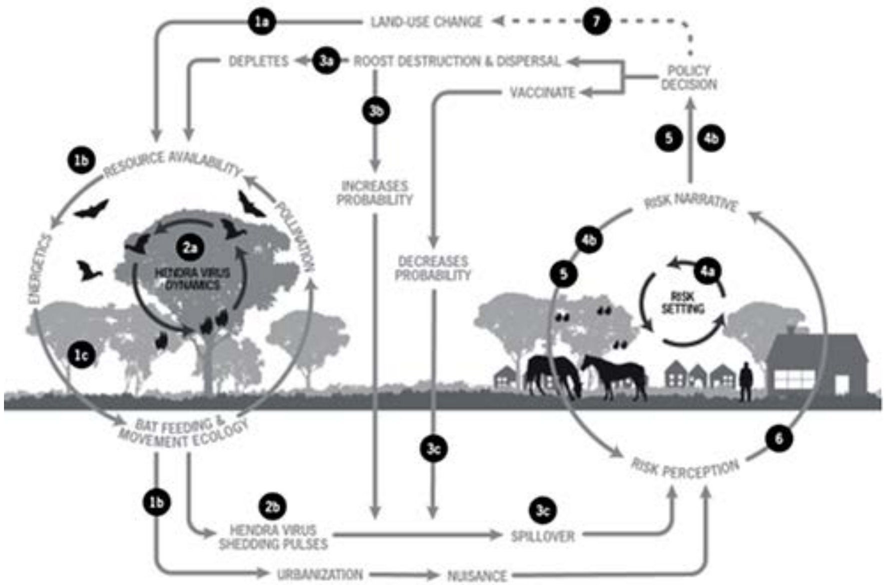
Temporal patterns of roost formation are correlated with Hendra virus spillover

Number of active roosts (95% HPD = 0.006–0.025) and number of roosts formed in the previous year (95% HPD = 0.03–0.07) are significantly correlated with number of Hendra spillover (GLM, negative binomial)





CNH-L: Dynamics of zoonotic systems: human-bat-pathogen interactions



RESEARCH TOPICS:

1. Viral dynamics
2. Links with environmental & behavioural change
3. Communications intervention
4. Ecological intervention

Case study Clunes, NSW winter 2017 & 2018: flying fox foraging movements, diet, and health

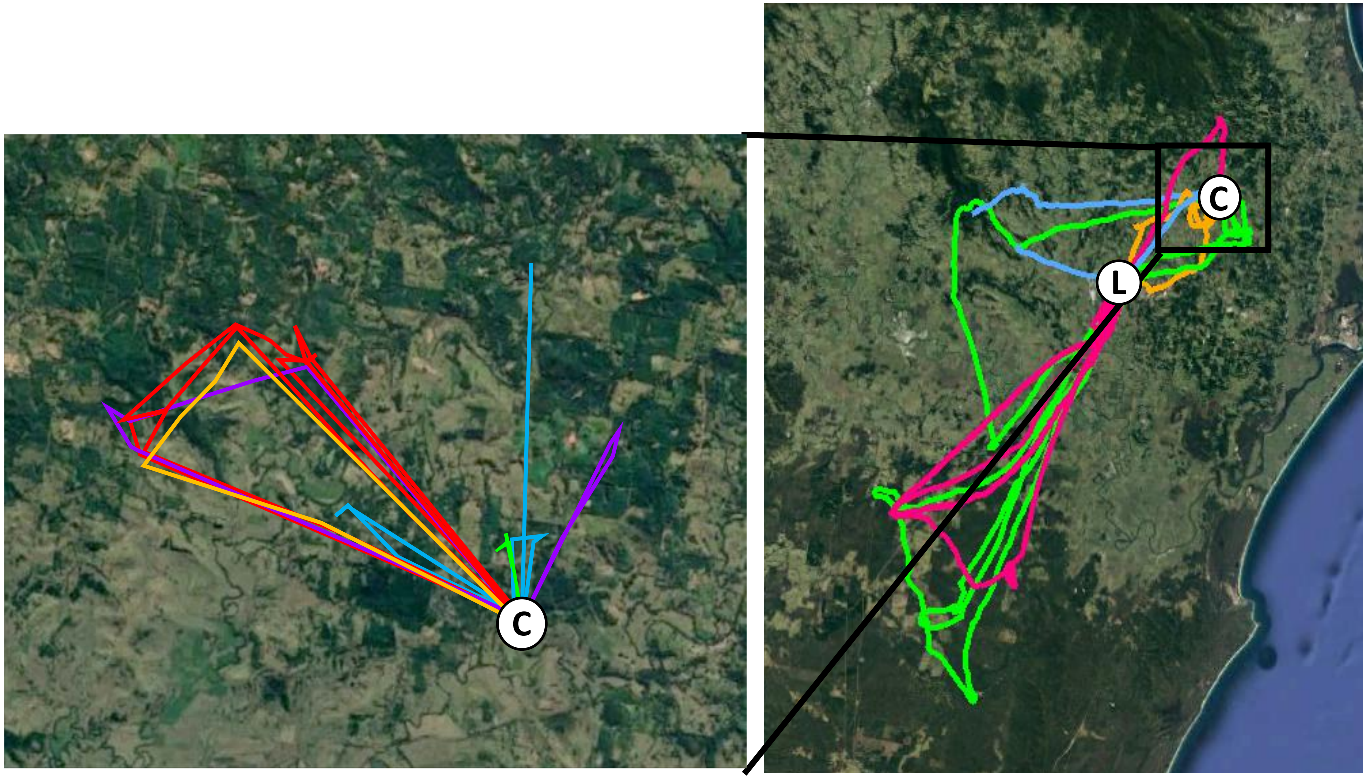
August 2017 – 2 HeV spillovers

August 2018 – 0 HeV spillovers

Camphor laurel

Privet

Mandarin



5.2 km = mean dist from roost

~40% of foraging stops in horse properties

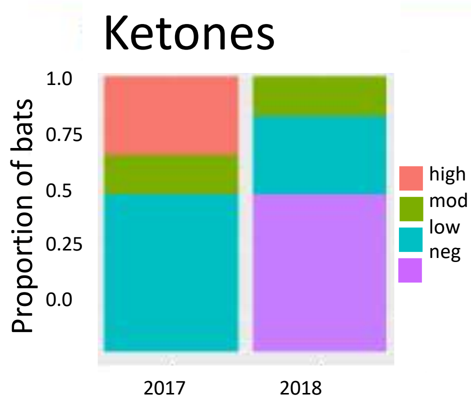
27.9 km = mean dist from roost

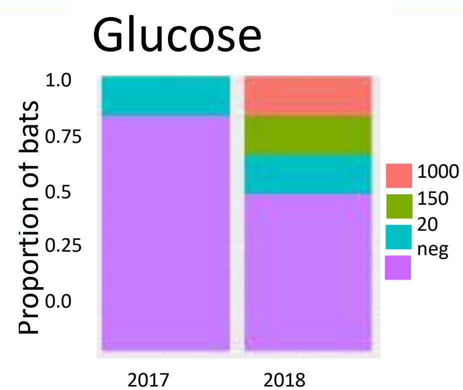
2% of foraging stops in horse properties

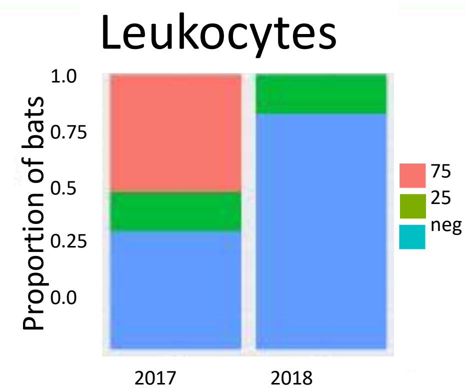
Nthn Grey Ironbark

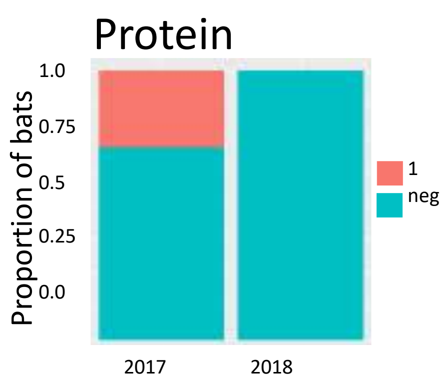
Forest Red Gum

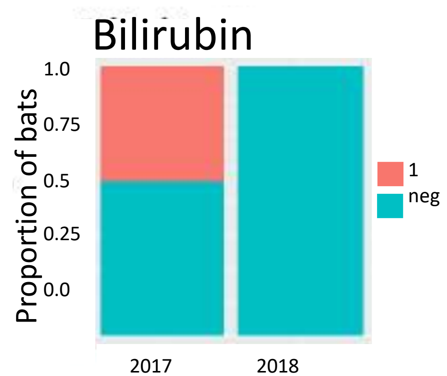
Case study Clunes, NSW winter 2017 & 2018: flying fox foraging movements, diet, and health

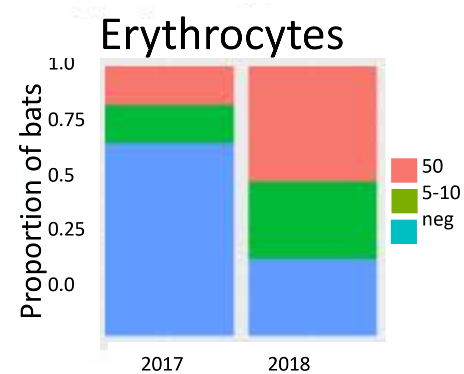


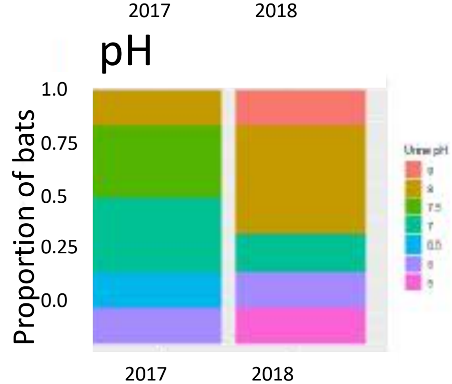


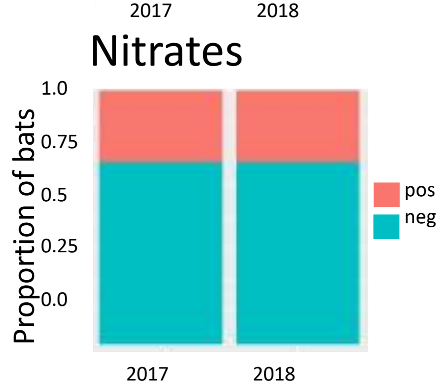












Preliminary results: differences in some nutritional and health-related biomarkers between years.

Can we reduce disease risk *(+ slow or reverse behavioural change & preserve pollination services)* using ecological interventions?

Approach: Engage existing government- and privately-funded habitat restoration initiatives in a program to target key winter diet species and provide food coincident with seasonal shedding pulses of Hendra virus.

THE CENTER FOR LARGE LANDSCAPE CONSERVATION

THE GREAT EASTERN RANGES connecting people...connecting nature

Healthy land & water

TWEED SHIRE COUNCIL

Brunswick Valley Landcare Inc.

Nomadic pollinators are in decline
What can we do?

Enhance critical winter feeding habitat as part of existing restoration and regeneration initiatives.

Prioritise plants that:

1) provide food during bottleneck periods (bridging plants) and
2) support diverse pollinator networks (framework plants).

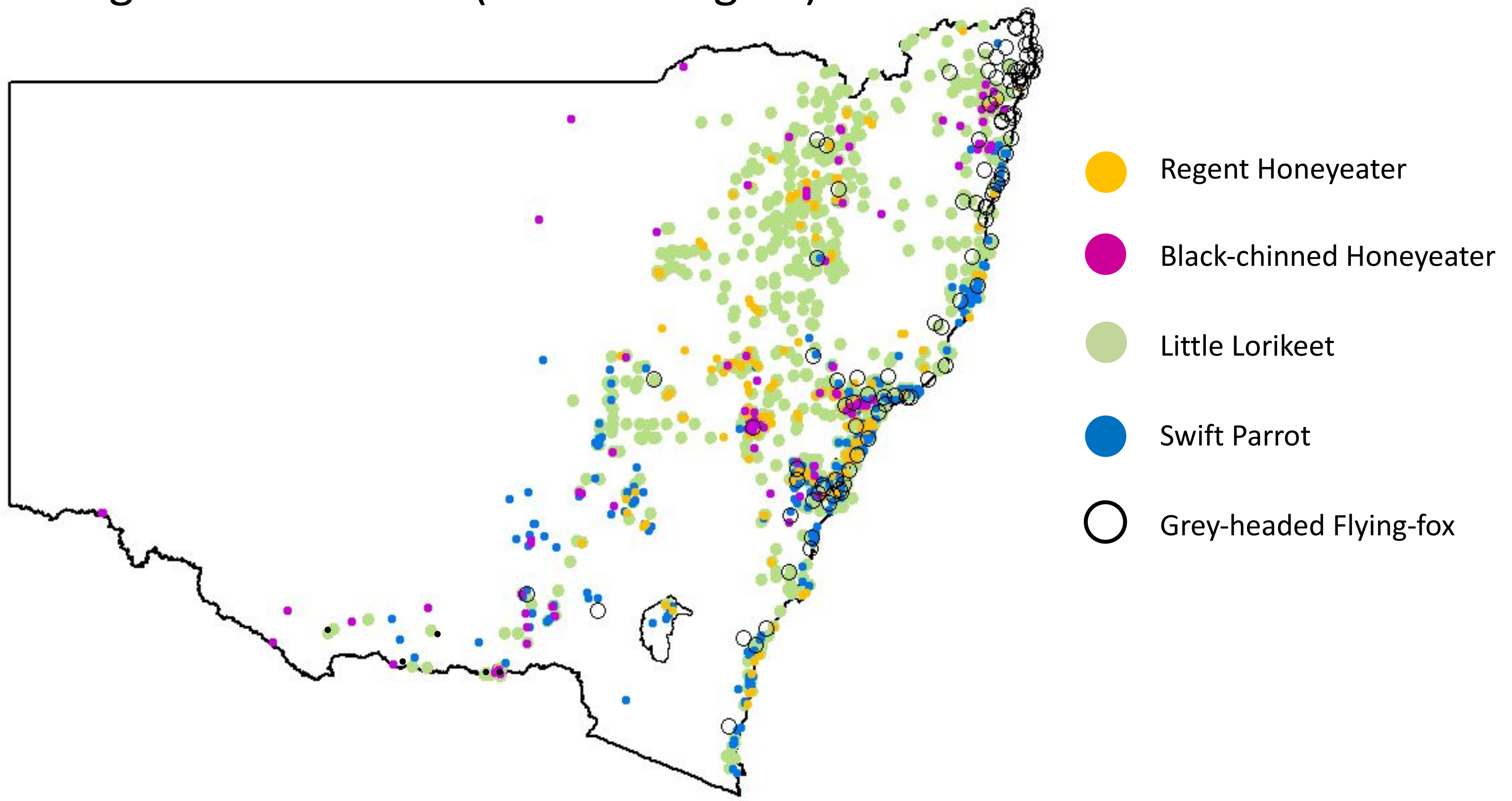
(Menz *et al*. 2011; Dixon 2009)





Associations between sightings of nomadic pollinators during winter months and winter-flowering diet species in NSW.

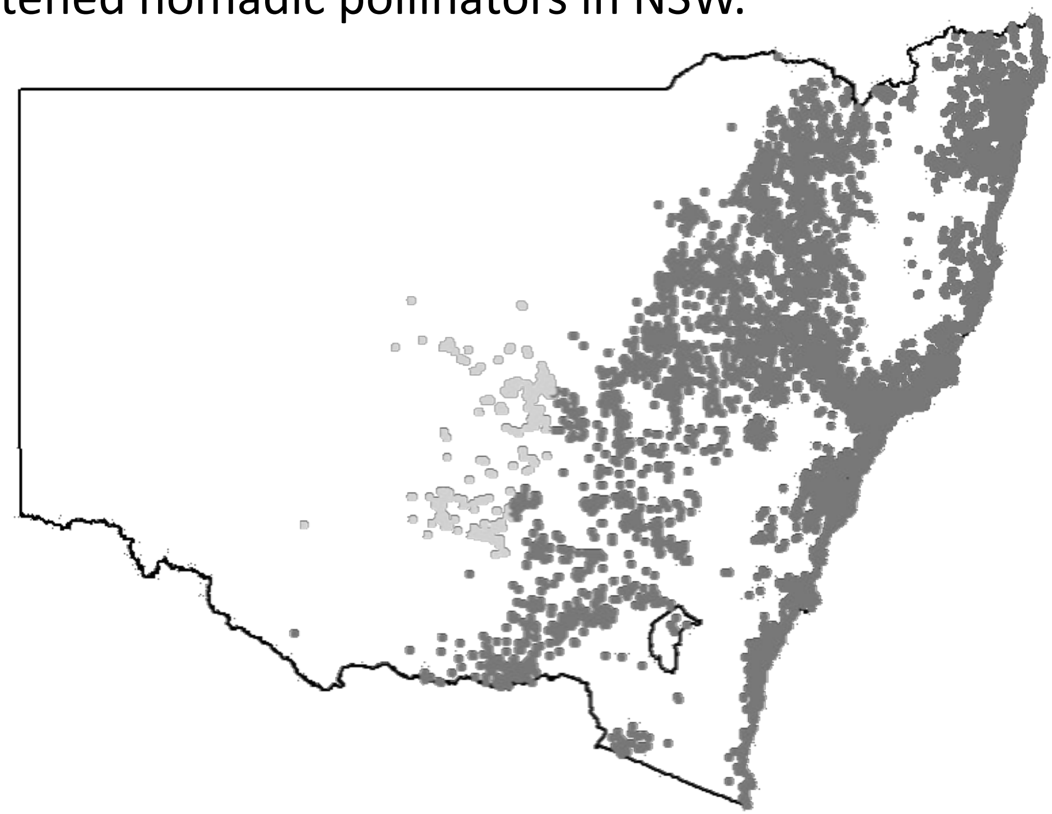
a) Recent sightings (1995 to present) of threatened nomadic pollinators in NSW during winter months (June to August).



Data for bird and tree species are from the Atlas of Living Australia (*accessed August 15, 2015*). Data for the Grey-headed flying-fox are based on winter occupation of known roost sites from the Atlas of Living Australia and the National Flying-fox Monitoring Program.

Associations between sightings of nomadic pollinators during winter months and winter-flowering diet species in NSW.

b) Distribution of winter-flowering food trees in the diet of threatened nomadic pollinators in NSW.



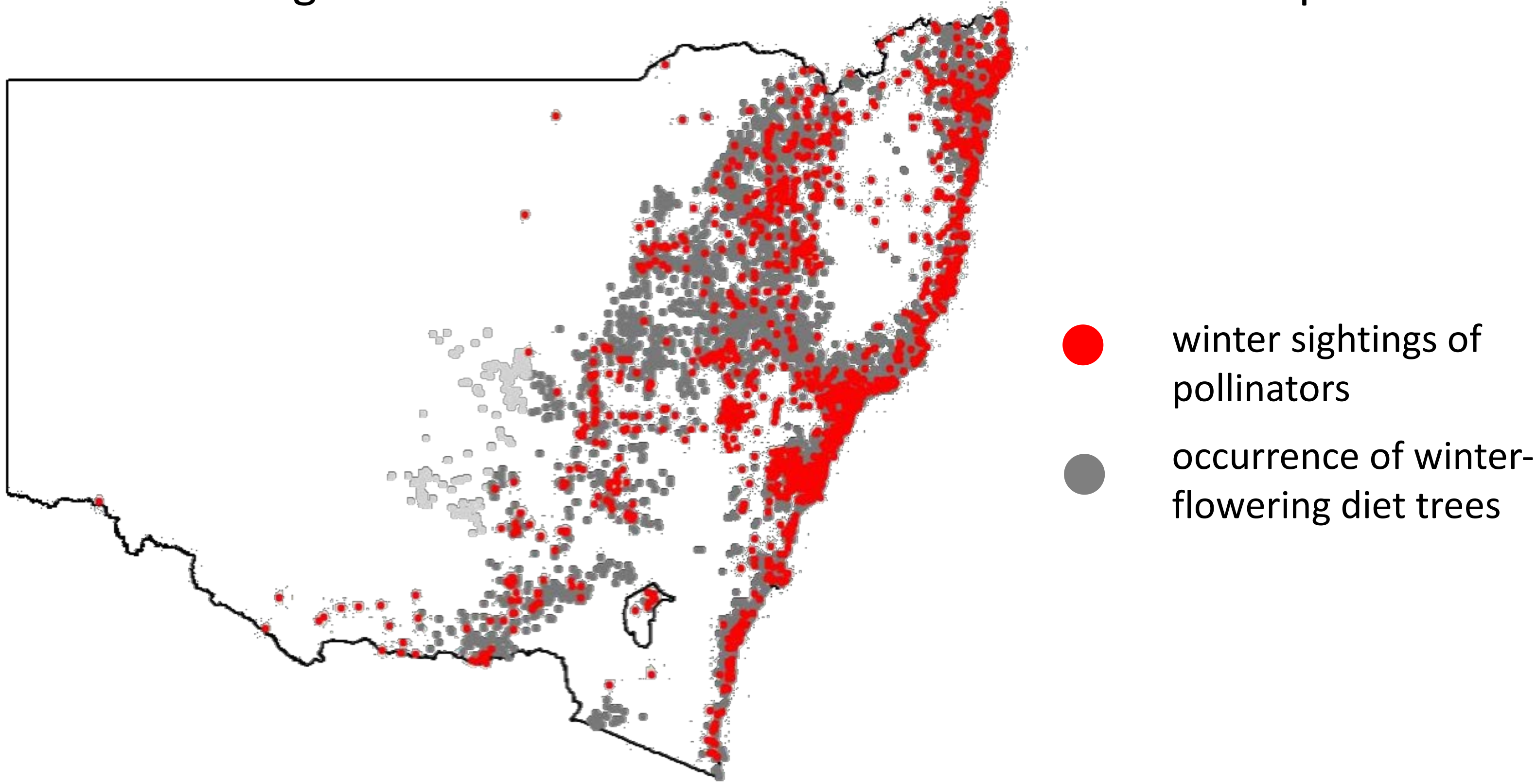
occurrence of winter-flowering diet trees

Mugga Ironbark
White Box
Forest Red Gum
Swamp Mahogany
Broad-leaved Paperbark
Coastal Banksia
Spotted Gum

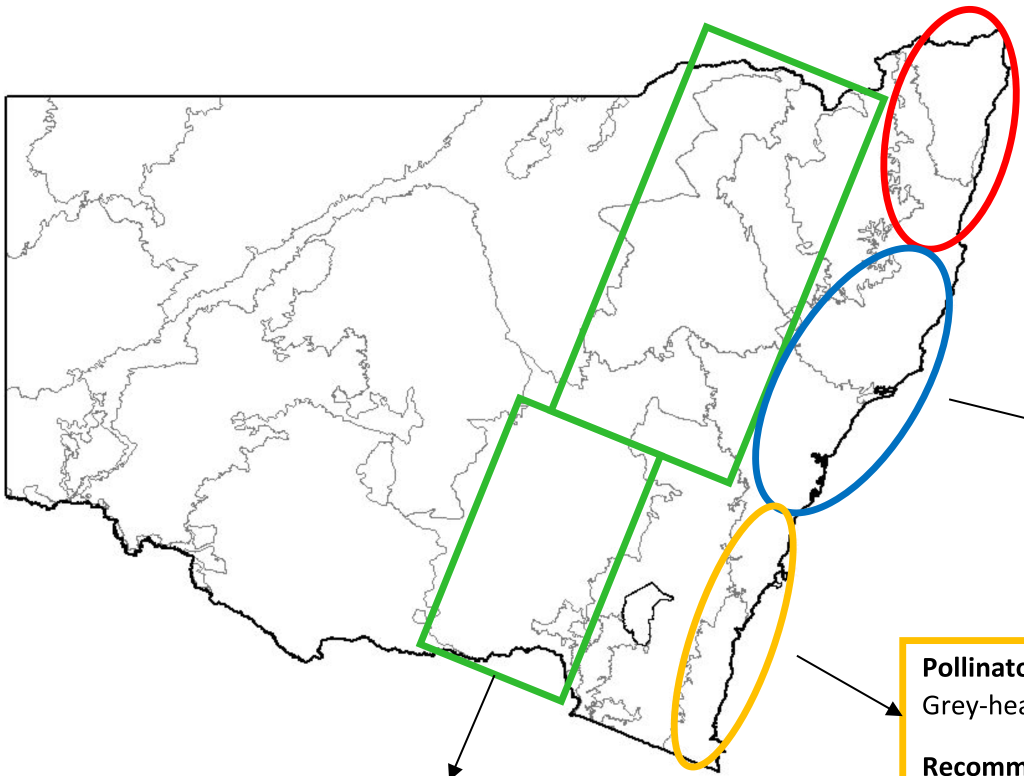
Atlas of Living Australia (*accessed August 15, 2015*).

Associations between sightings of nomadic pollinators during winter months and winter-flowering diet species in NSW.

c) Spatial associations between 5 species of threatened nomadic pollinators and winter-flowering food trees in coastal lowlands and western slopes of NSW.



Recommendations for restoration plantings, natural regeneration and habitat restoration to enhance winter & spring food for nomadic long-distance pollinators in NSW.



Pollinators: Regent Honeyeater, Black-chinned Honeyeater, Little Lorikeet, Swift Parrot, Grey-headed Flying-fox

Recommended for planting:
winter: Coast Banksia, Grey Ironbark, Forest Red Gum, Swamp Mahogany, Broad-leaved Paperbark;
early spring: Narrow-leaved Red Gum, Turpentine

Pollinators: Regent Honeyeater, Black-chinned Honeyeater, Little Lorikeet, Swift Parrot, Grey-headed Flying-fox

Recommended for planting:
winter: Coast Banksia, Swamp Mahogany, Mugga Ironbark (Sydney Basin), Spotted Gum (Lower Hunter);
early spring: Grey Ironbark, Turpentine

Pollinators: Regent Honeyeater, Little Lorikeet, Swift Parrot, Grey-headed Flying-fox

Recommended for planting:
winter: Coast Banksia, Spotted Gum, Swamp Mahogany;
early spring: Forest Red Gum, Grey Ironbark

Pollinators: Regent Honeyeater, Black-chinned Honeyeater, Little Lorikeet, Swift Parrot, Grey-headed Flying-fox

Recommended for planting:
winter: White Box, Mugga Ironbark;
early spring: Yellow Box, Inland Grey Box

Nomadic pollinators are in decline
What can we do?

Increase knowledge base and resources:
(funding /support from GER, HL&W, CNH, DARPA, Griffith U)

1. Validate & refine strategy
    a) characterise suitable restoration sites
    b) confirm current behaviours reverse under suitable conditions

2. Develop communications materials (GER, CNH)
    a) web site, brochures, etc





The potential benefits of this approach

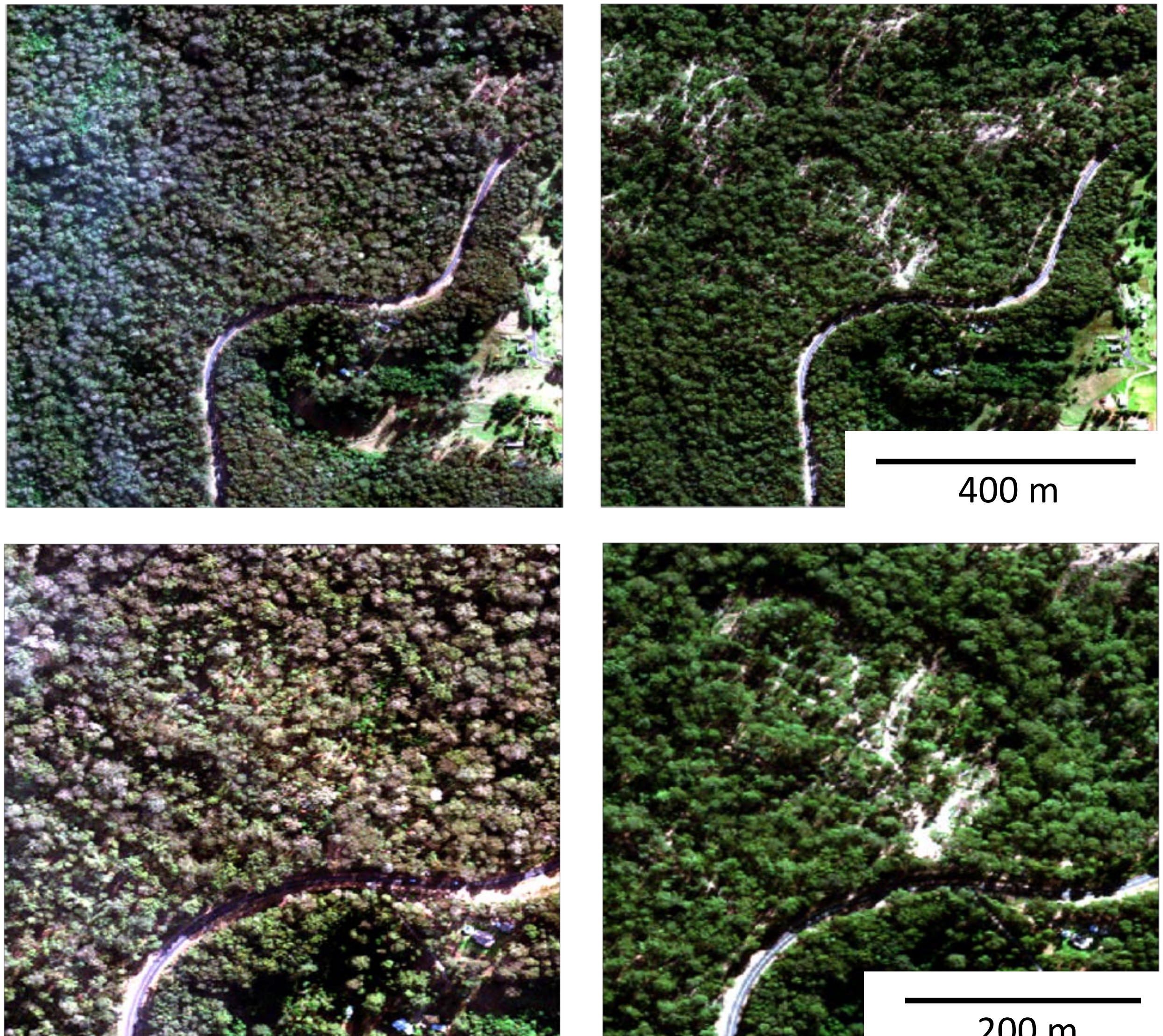
Using restoration and regeneration plantings to enhance winter feeding habitat for threatened nomadic pollinators would:

- assist with conserving broader pollinator networks;
- build resilience in plantings and natural systems;
- embed plantings in ecological processes that play out over large spatial scales;
- amplify the benefits of local conservation efforts;
- . aid in conserving endangered ecological communities;
- assist with flying-fox camp management issues.

Using satellite imagery to track flowering events

Spotted Gum forest Batemans Bay: Digital Globe 30 cm resolution

May 2016 | May 2018



Aims:

- Document fine-scale habitat change over time
- Define spectral signatures associated with flowering
- Track flowering events in time and space

Acknowledgements

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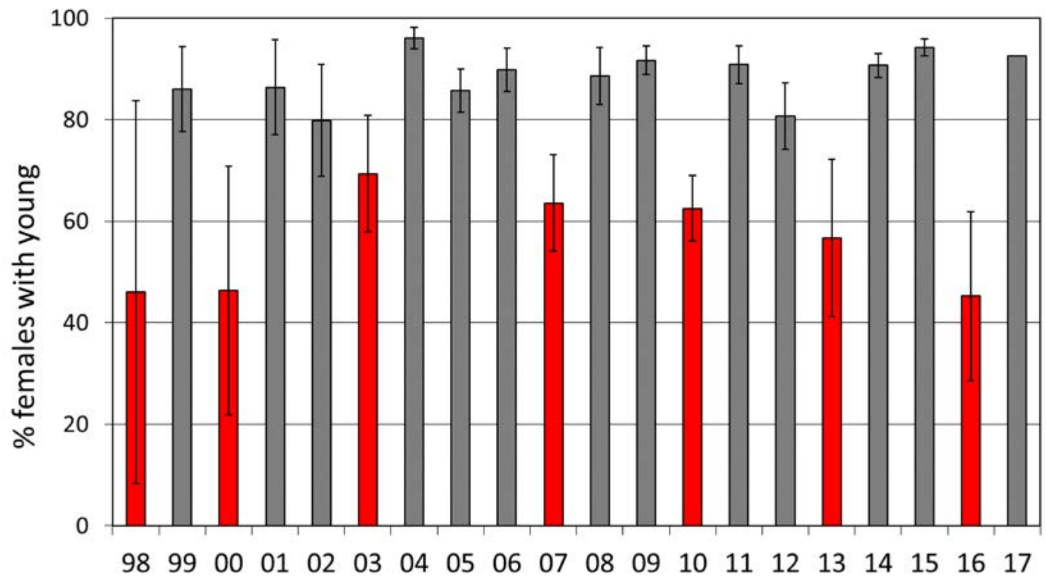
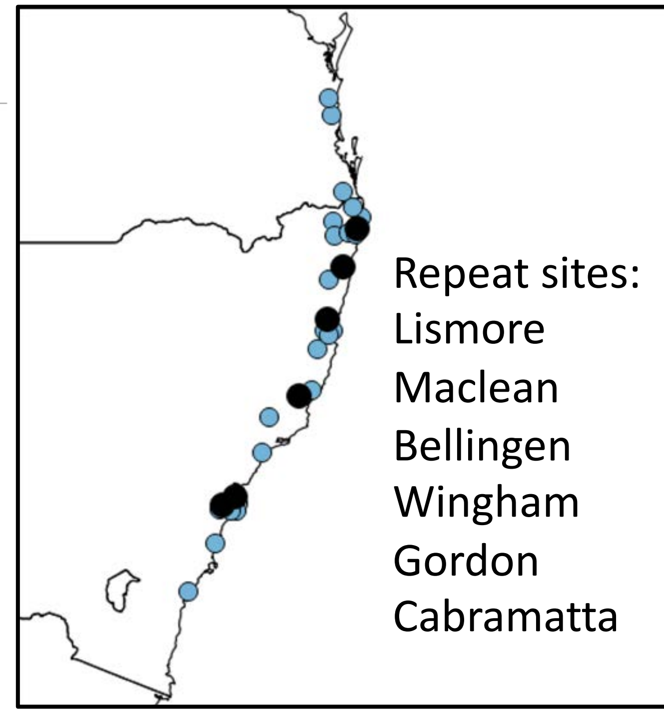
R. Gough - Northern Rivers Wildlife Carers
L. Collins
... and many, many others

Are behavioural changes increasing fitness?

% females with young pre-weaning

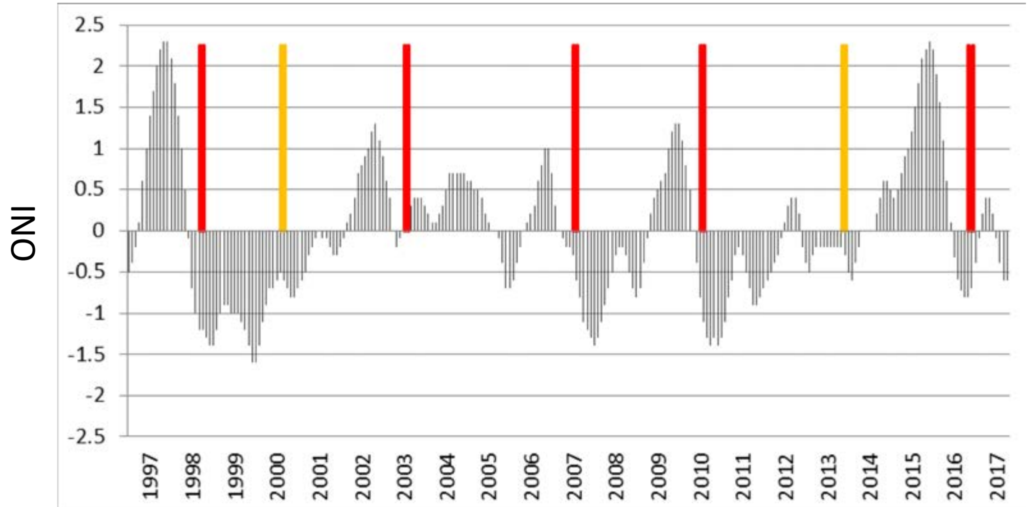
Mean, 95% CI, 20 years, 6 repeat sample sites

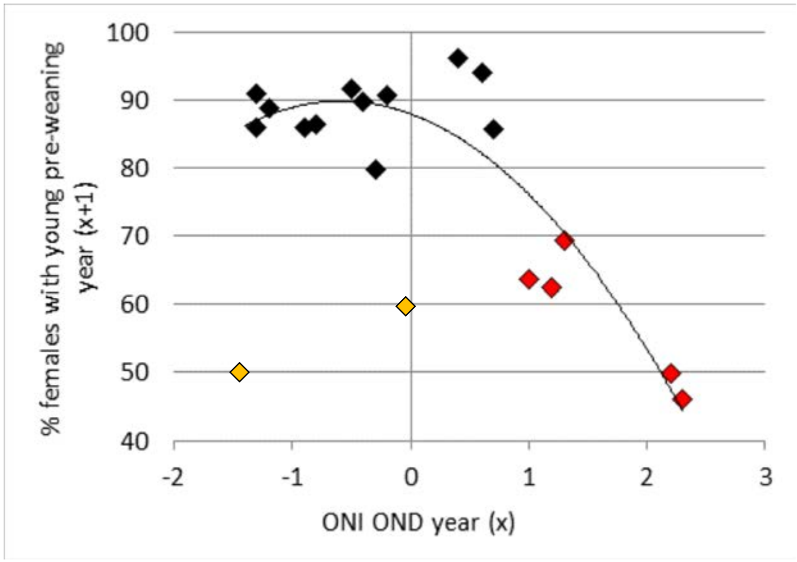




There is evidence that moderate to strong el niño (ONI ≥0.9) is predictive of acute food shortage

severe el niños are followed by acute food shortages (lag 9-12mths), but not all acute shortages are associated with severe el niño





? change in ONI tracks change in reproductive marker of food shortage

Hypotheses:

(*H1) Loss of reliable winter / spring feeding habitat is a key driver of behavioural change.*

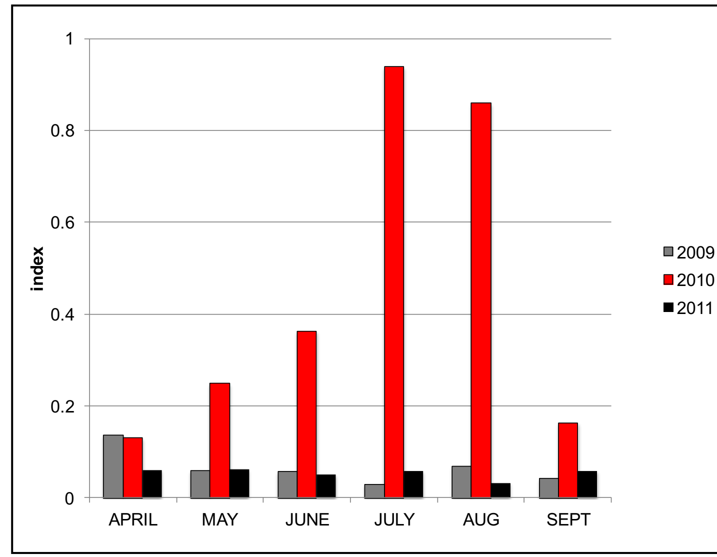
(H2) Behavioural changes indicate chronic nutritional / metabolic stress.

(H3) Animals experiencing these conditions are susceptible to viral infection leading to Hendra virus shedding.


TAKE
BACK
BURDEKIN
PARK

New camps form during acute food shortages

150.718 - male



Monthly counts of flying-foxes encountered by WIRES groups in the inner suburbs of Sydney, scaled to the estimated population size of camps in the area.

16/6 to 18/6/2010

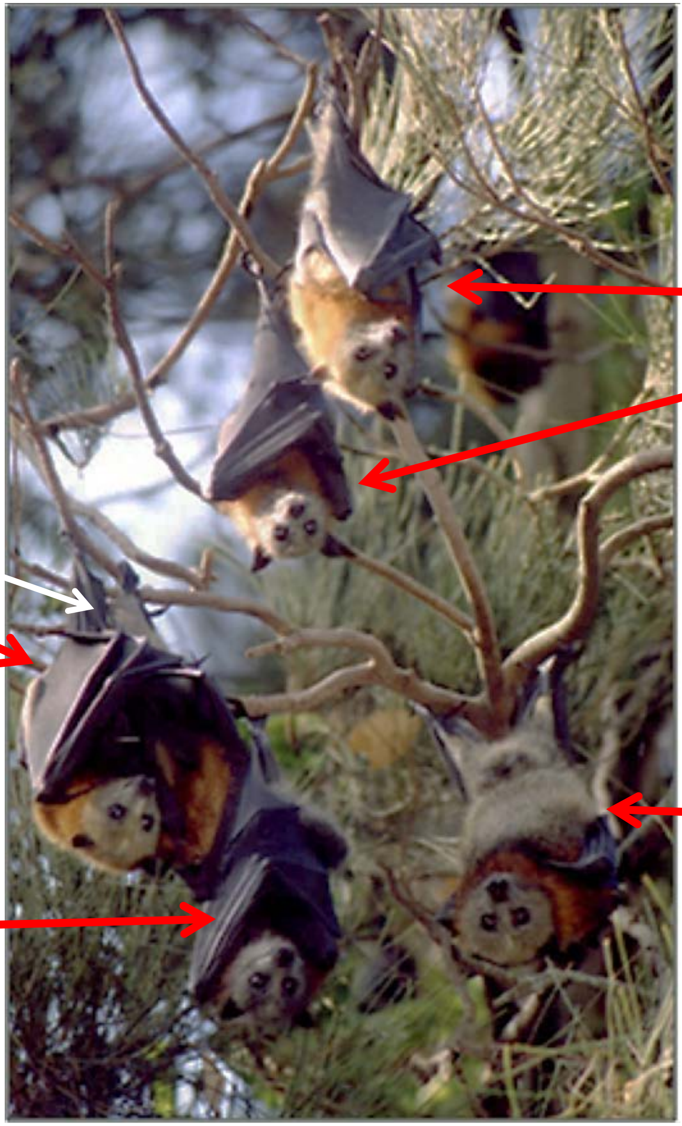
20/6 to 20/7/2010

24/7 to 27/8/2010

September – November 2010

The Centennial Park roost formed during the 2010 food shortage and has persisted.

Adult mixed sex group



female & her young

female with young in wings

male

female without young

Roost structure and group composition

individual roosting positions are stable

4 January

3 February

2 March

Female reproductive cycle - GHFFs

gestation – 6 mths

conception
April-May

birth
Sept-Nov

lactation – 5 mths

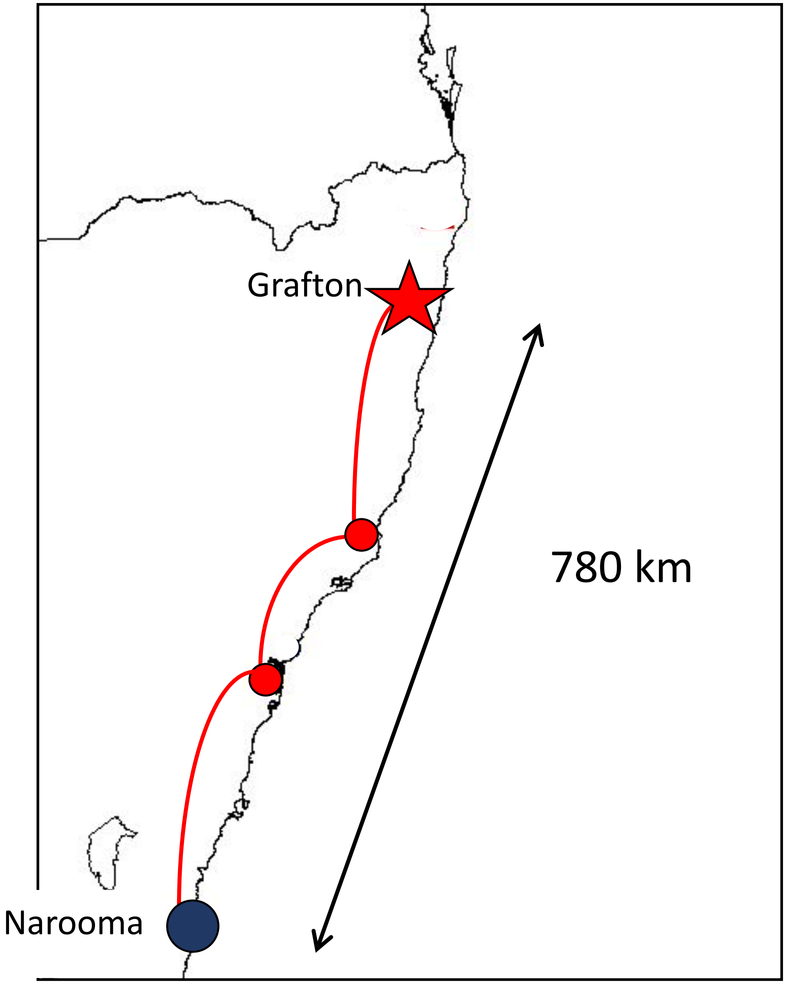
Roles of camps

resting habitat
close to food

Roles of camps

assist with migration

- predictable stopover habitat
- sites of information exchange



Eby (1991)

Roles of camps

sites of significant behaviours
e.g. *reproduction*



Roles of camps

night refuge for flightless young

Pollinators are in decline
Why should we care?

Plant-pollinator mutualisms are fundamental to ecosystem functions in natural and agricultural systems.





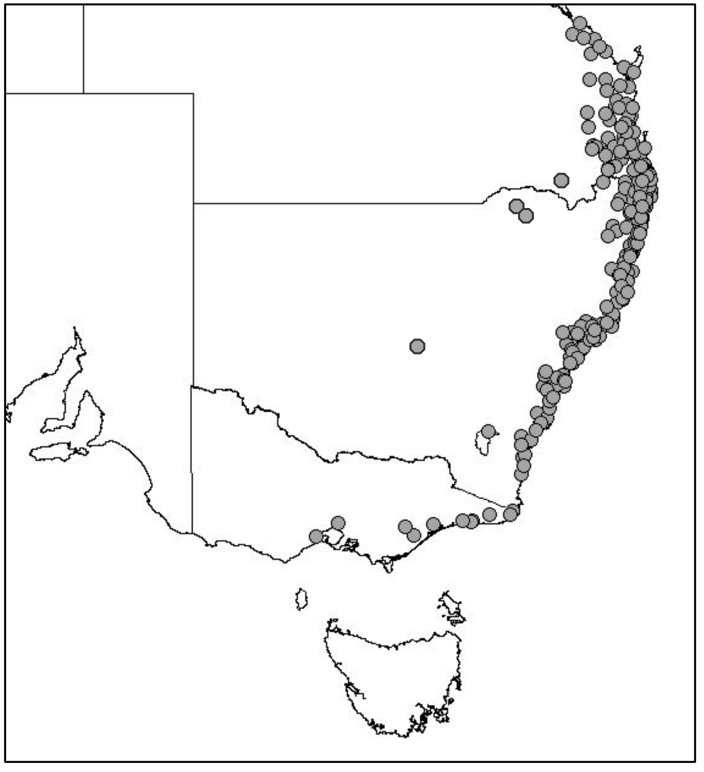
Pollinators are in decline
Why should we care?

Bird and mammal pollinators listed as threatened in New South Wales.

Common name	Conservation Status in NSW	Nomadic canopy-feeders
BIRDS		
Regent Honeyeater	Critically Endangered	*
Swift Parrot	Endangered	*
Mangrove Honeyeater	Vulnerable	
Black-chinned Honeyeater	Vulnerable	*
Purple-crowned Lorikeet	Vulnerable	
Little Lorikeet	Vulnerable	*
Pied Honeyeater	Vulnerable	
MAMMALS		
Grey-headed Flying-fox	Vulnerable	*
Common Blossom Bat	Vulnerable	
Eastern Pygmy Possum	Vulnerable	
Yellow-bellied Glider	Vulnerable	
Squirrel Glider	Vulnerable	

New roosts form during acute food shortage

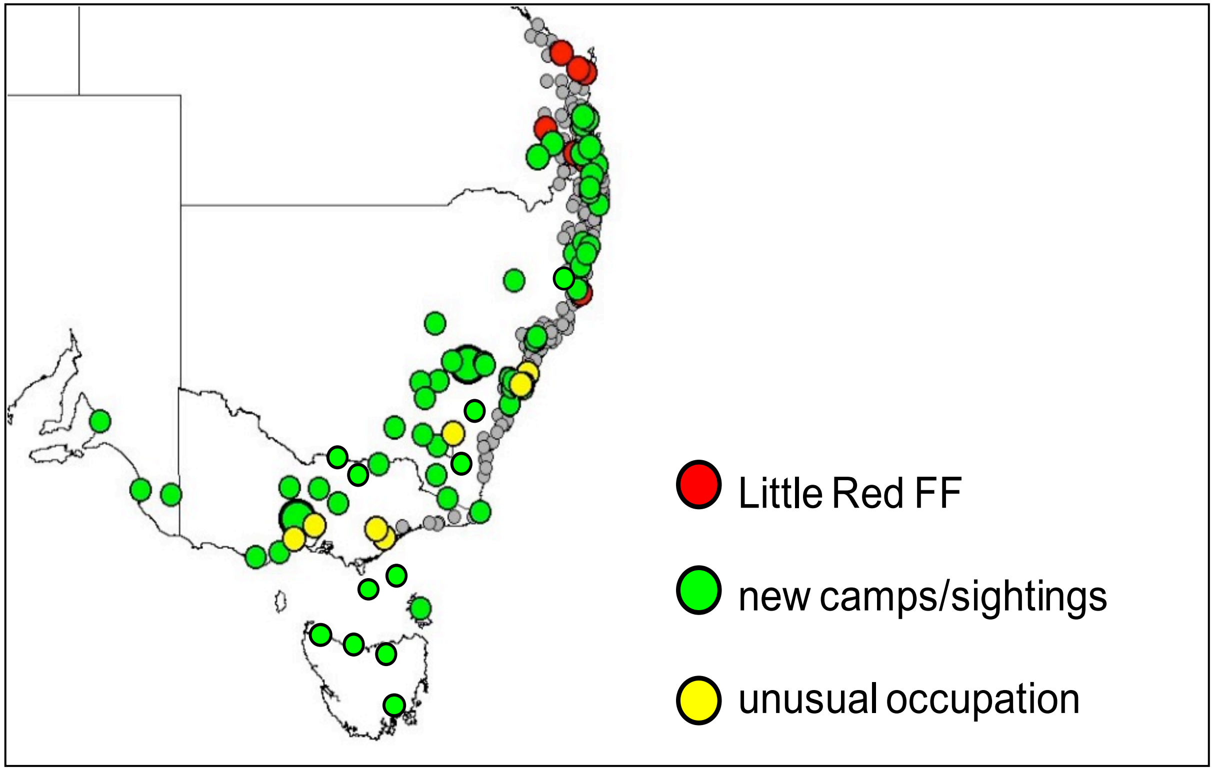
Distribution of flying-fox roosts in south-east Australia pre-2010 food shortage



New roosts form during acute food shortage

Incursions into atypical (marginal?) habitats - 2010

Observations of flying-foxes in unexpected locations during 2010 food shortage



Data sources:
- field monitoring programs
- field ecologists / naturalists
- internet surveillance
- general public

92 localities
72 aggregations of >50 GHFFs

New roosts form during acute food shortage

Incursions into atypical (marginal?) habitats - 2010

68% of the roosts that formed during 2010 have persisted