Flying-foxes and extreme heat events: impacts and responses

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Tropical Biodiversity & Climate Change

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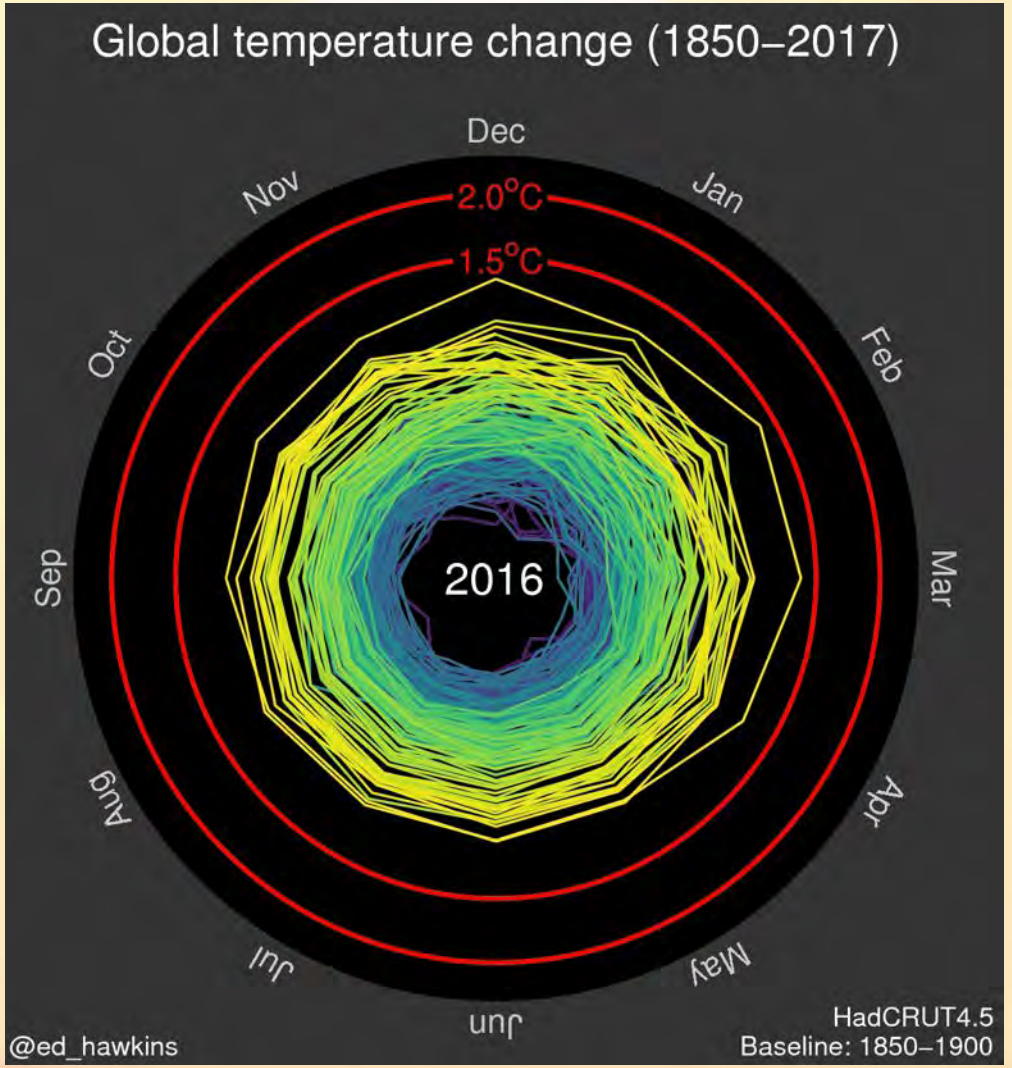
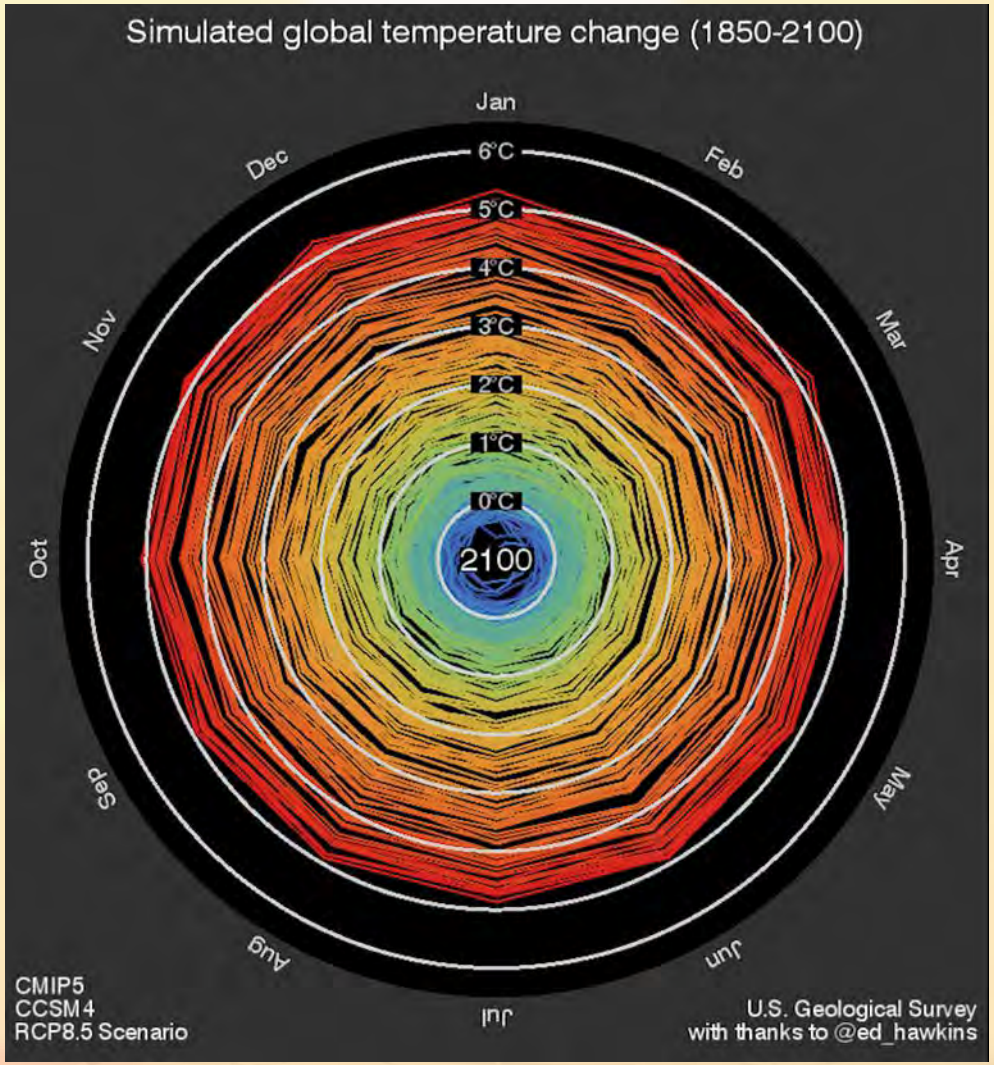
Our world is warming

The instrumental record shows a clear upward trends in global land and ocean temperatures since the early 20th century



Our world is warming

These upward trends are expected to escalate into the 21st century

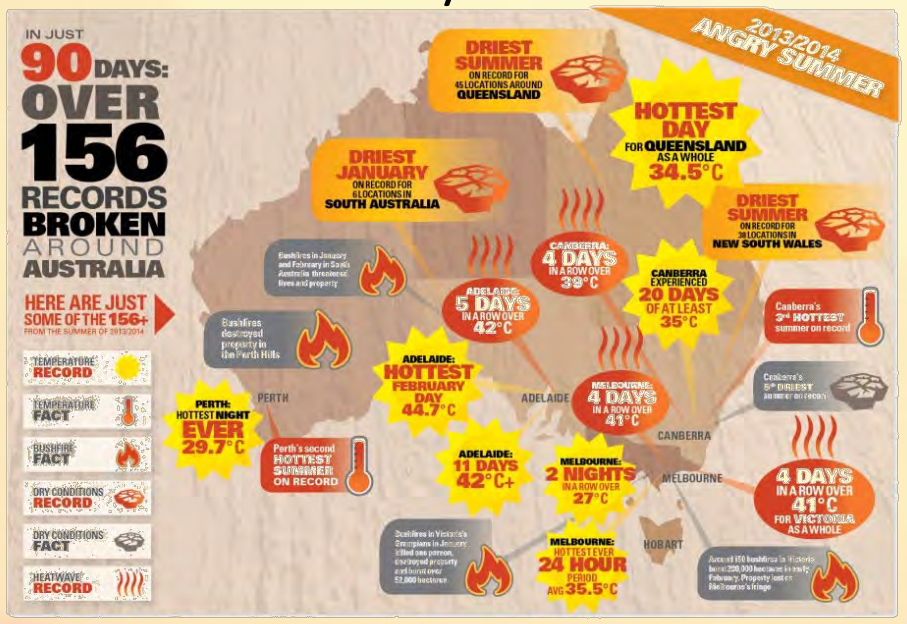


Our world is warming

There is little doubt that our summers will become hotter (or more ‘angry’)

2012/2013

2013/2014



What are the impacts of extreme heat events on biodiversity?

Impacts of extreme heat events on flying-foxes, *Pteropus* spp.

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Welbergen, J.A. 2005. The social organisation of the grey-headed flying-fox, *Pteropus poliocephalus* (PhD thesis, University of Cambridge)

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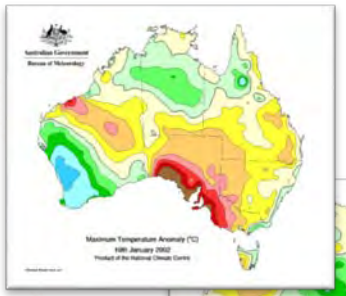
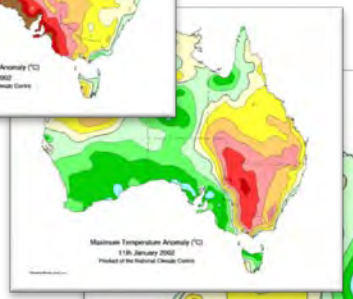
2002 Northern NSW extreme heat event

Jan 10th:

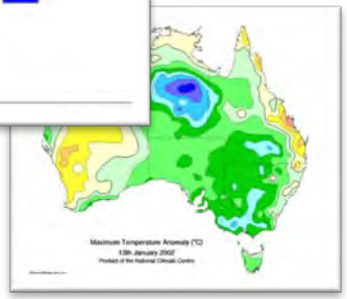


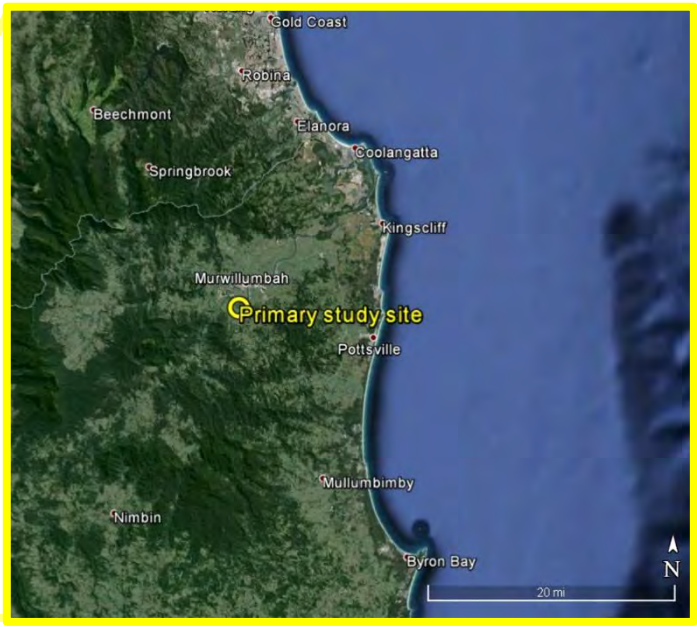
Jan 11th:



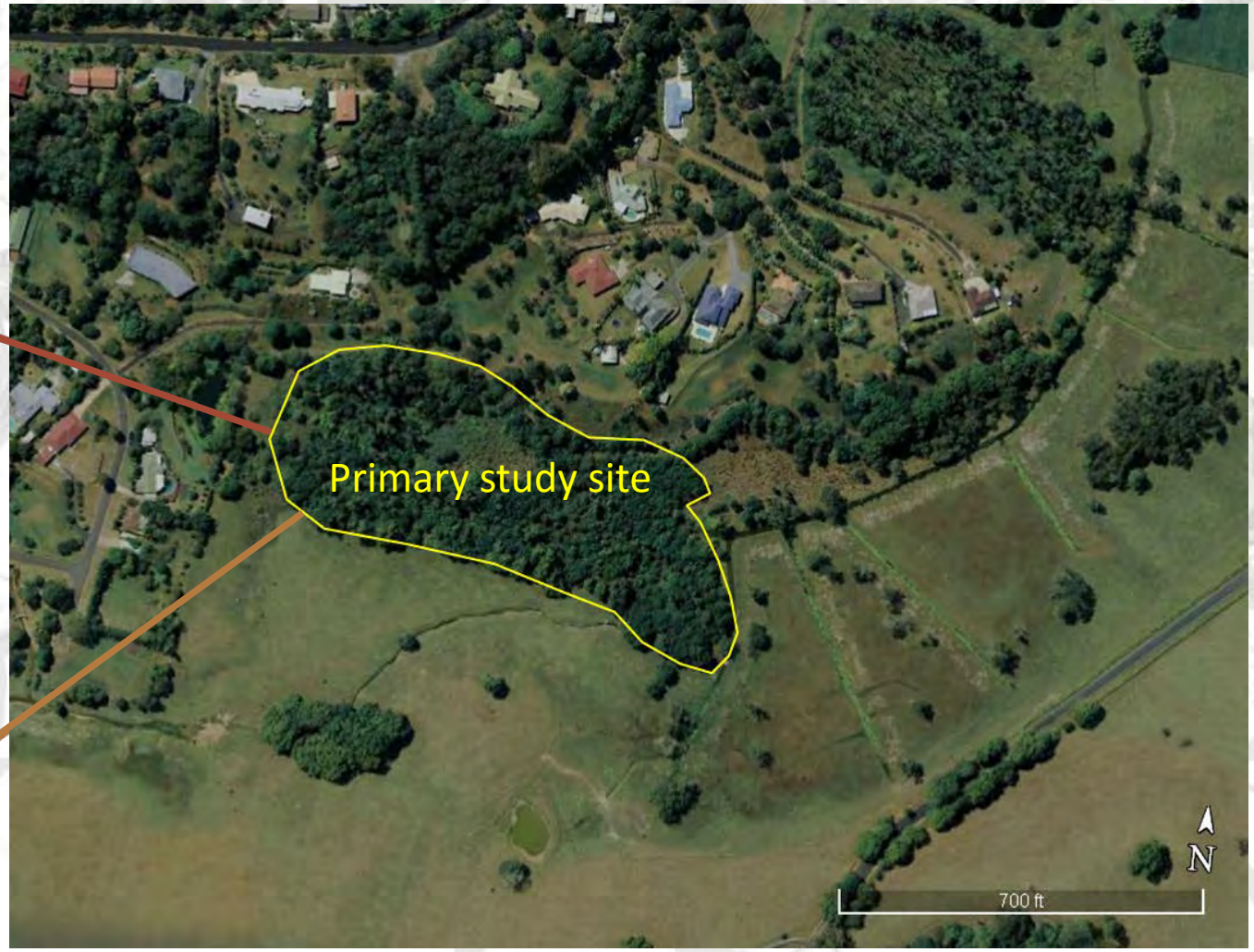
Jan 12th:

Jan 13th:



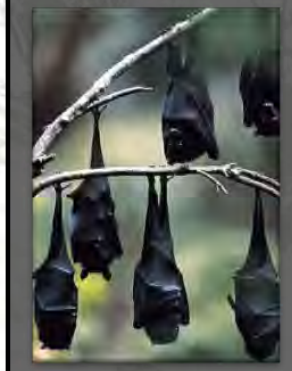


Study site contained two species: the black flying-fox and the grey-headed flying-fox



.. with similar ‘slow-lane’ life-histories and food preferences

Black flying-fox



Grey-headed flying-fox

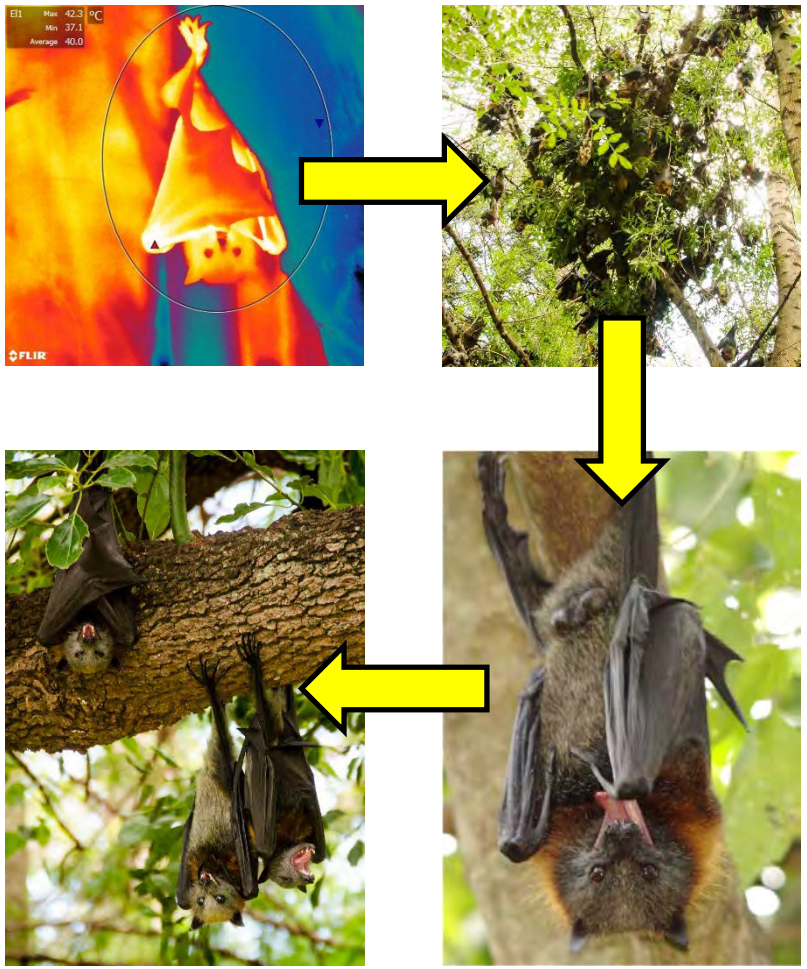
- Adult weight: 600-1100 g
- Wingspan: 1.2 - 1.6 m

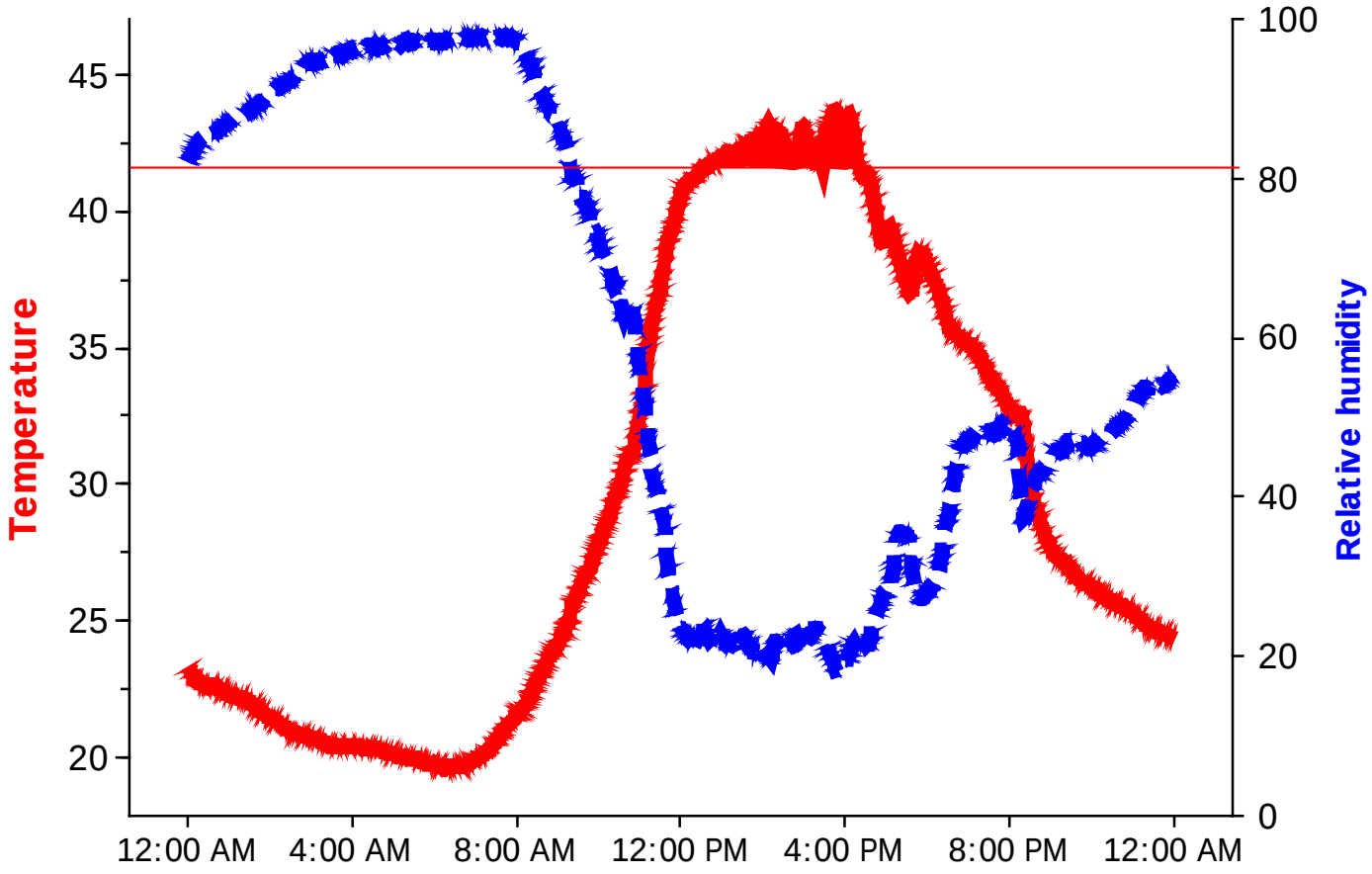
- Number of young: 1/year
- Time to mature: 18-36 months
- Maximum age: 15-21 years

- Food: nectar, pollen, fruit

Welbergen, 2011 *Oecol* 165, 629-637
Welbergen, 2010 *J Mamm 91:38-47*
Welbergen, 2006 *Behav Ecol and Sociobiol*, 60: 311-322

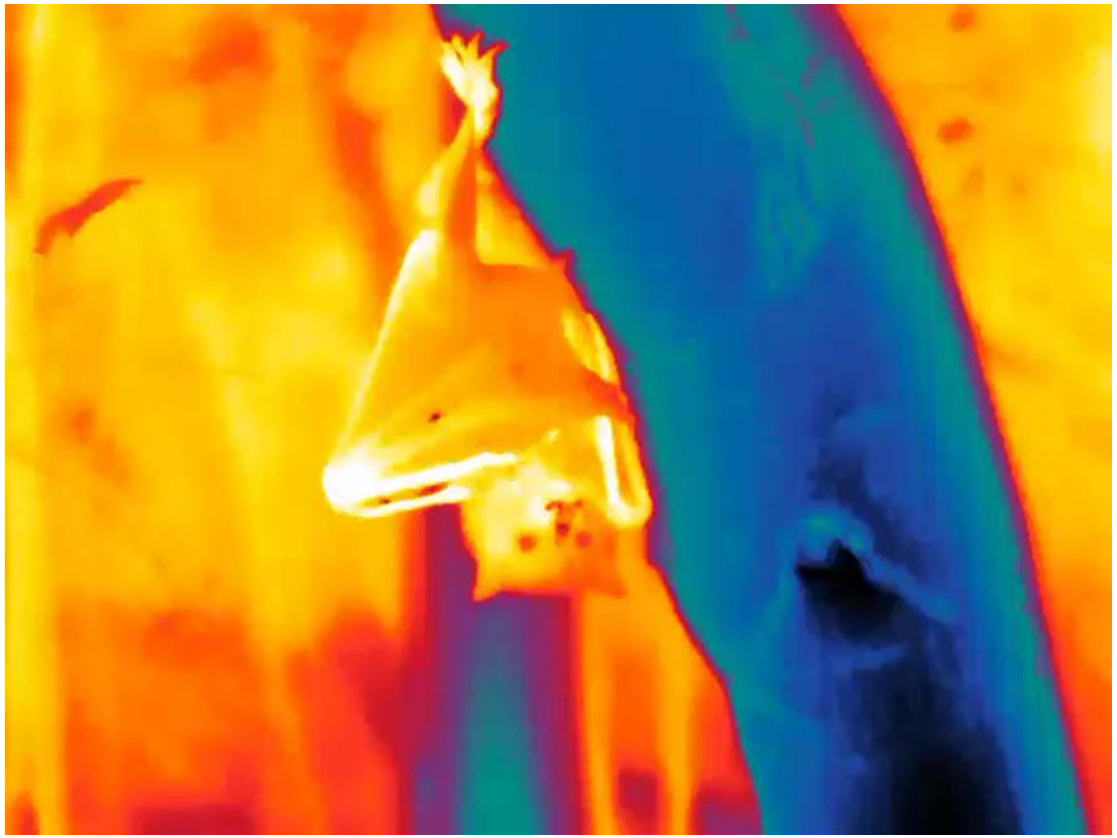
Flying-foxes show a predictable sequence of thermoregulatory behaviours

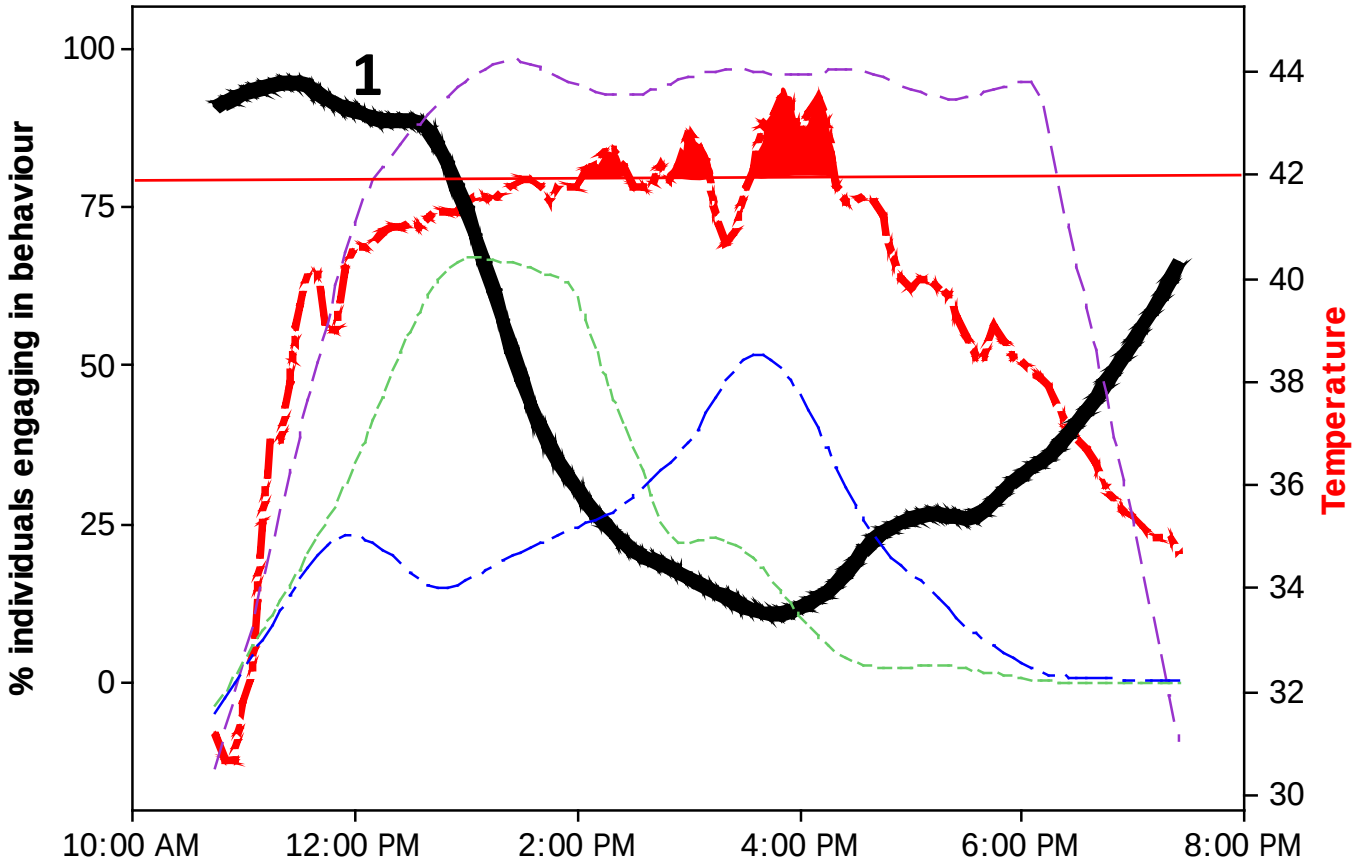




Welbergen, 2012 ISBN: 978-84-87790-69-0
Welbergen *et al,* 2008 *Proc Roy Soc B,* 275, 419-425

1. Wing fanning

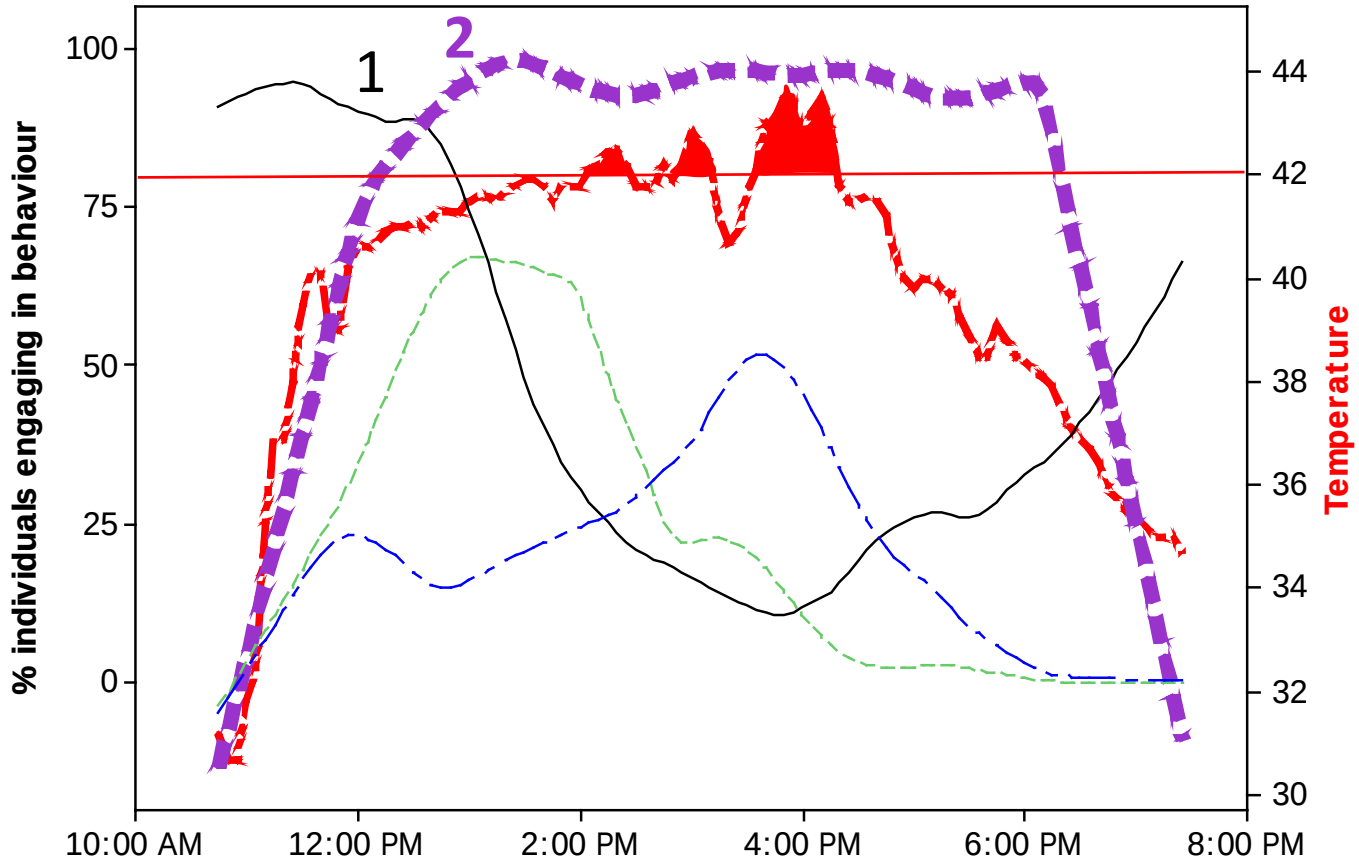




Dalziell & Welbergen, unpublished

Welbergen *et al,* 2008 *Proc Roy Soc B,* 275, 419-425

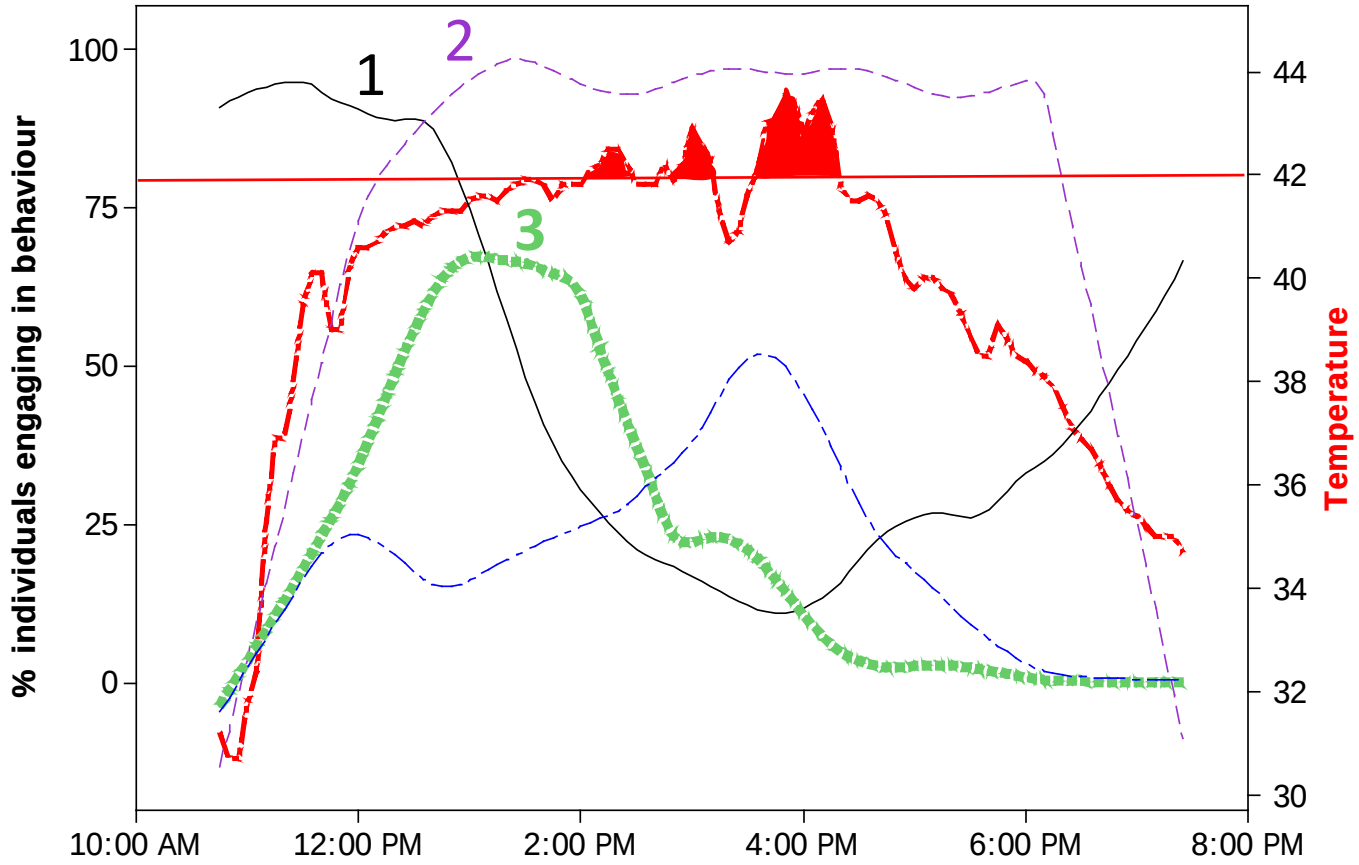
2. Clustering/clumping



Dalziell & Welbergen, unpublished

Welbergen *et al,* 2008 *Proc Roy Soc B,* 275, 419-425

3. Salivation



Dalziell & Welbergen, unpublished

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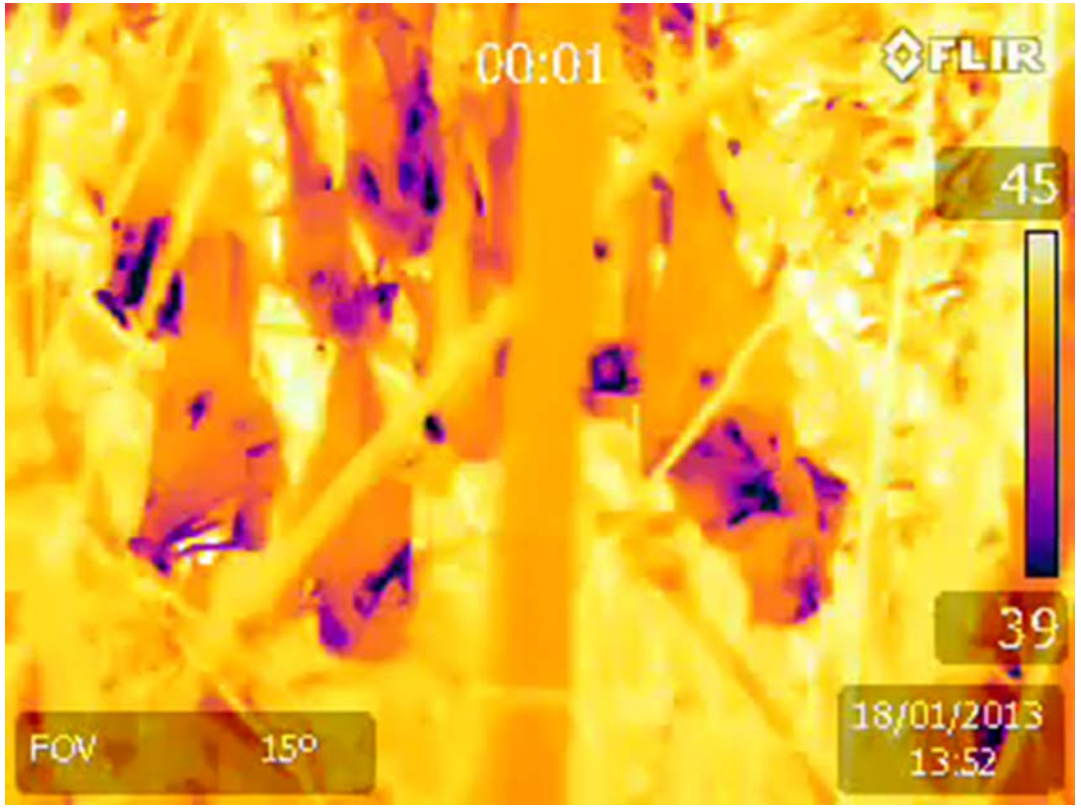
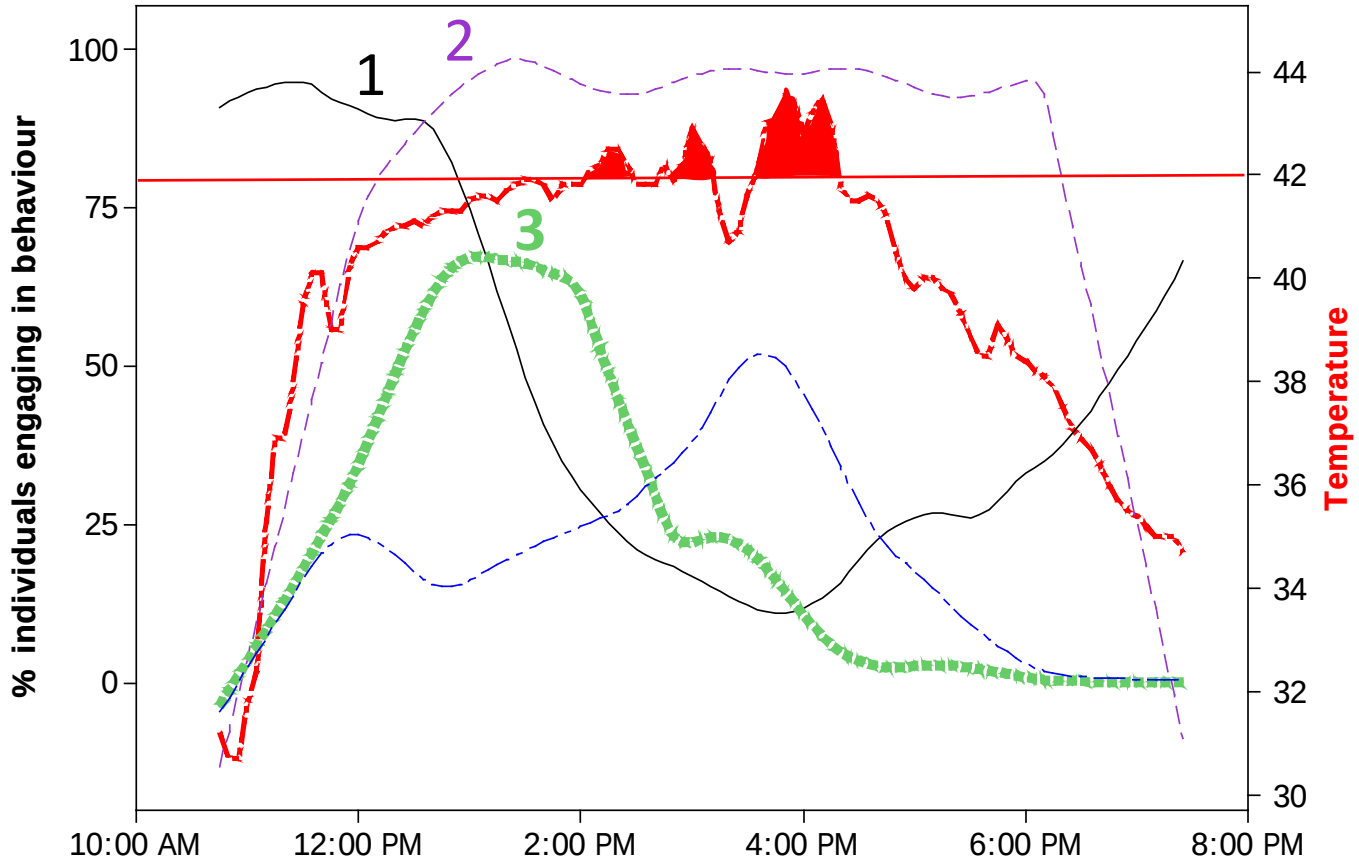
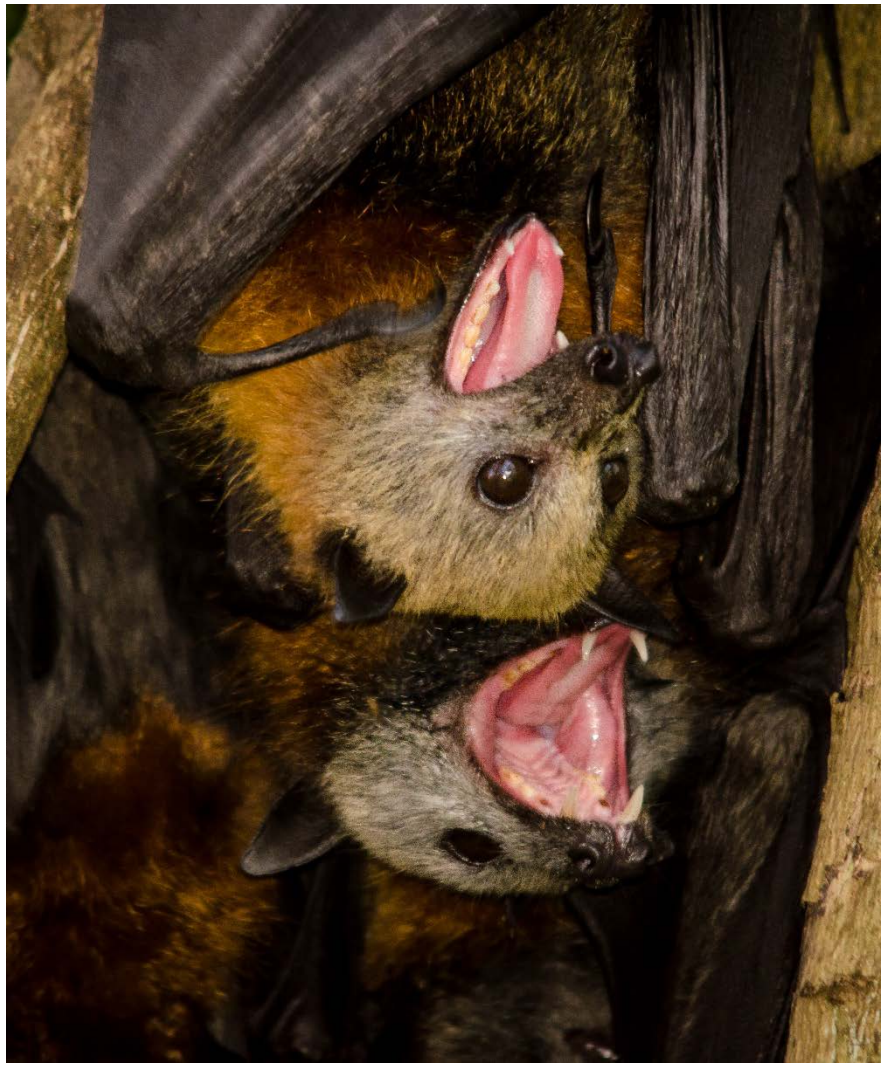


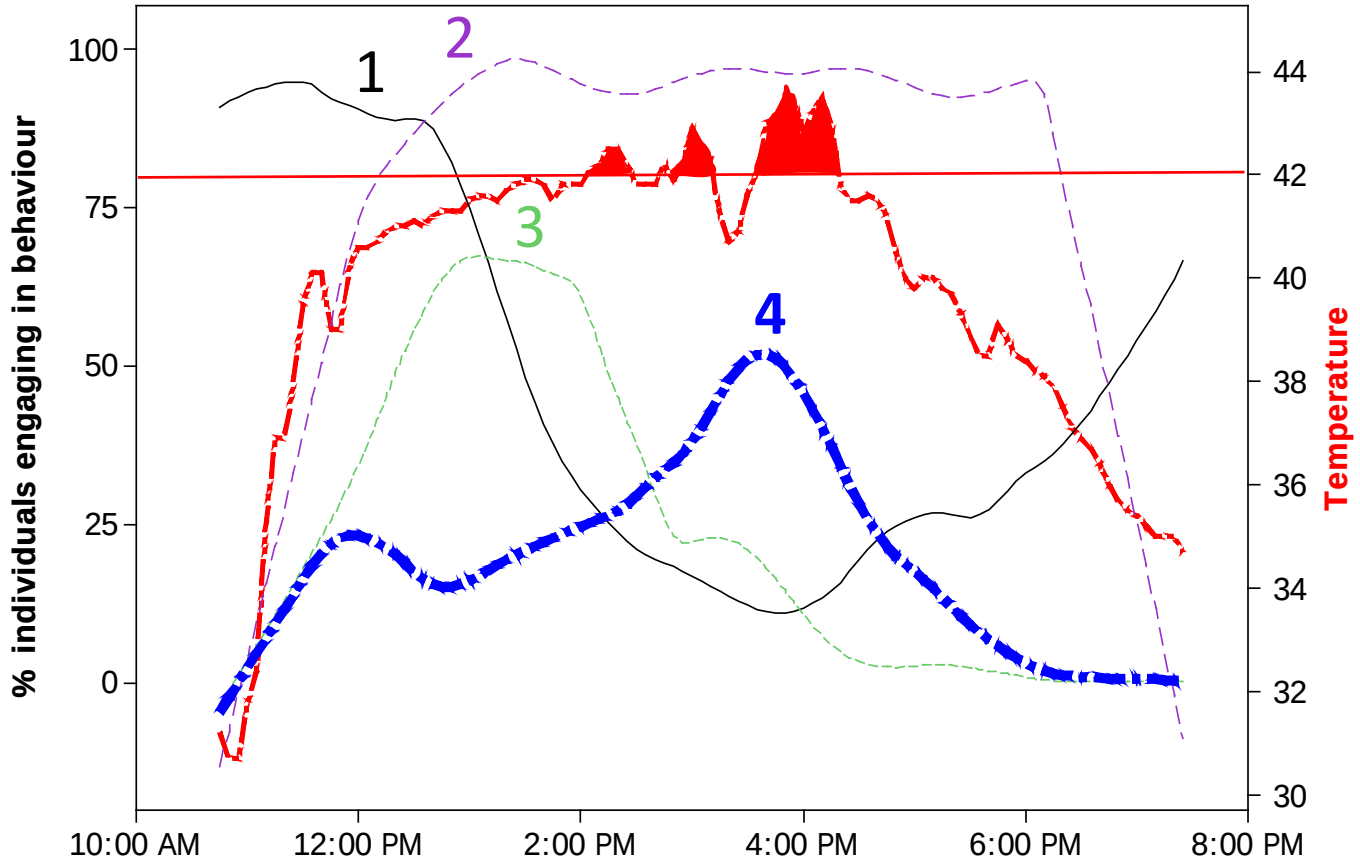


Dalziell & Welbergen, unpublished

Welbergen *et al,* 2008 *Proc Roy Soc B,* 275, 419-425

4. Panting

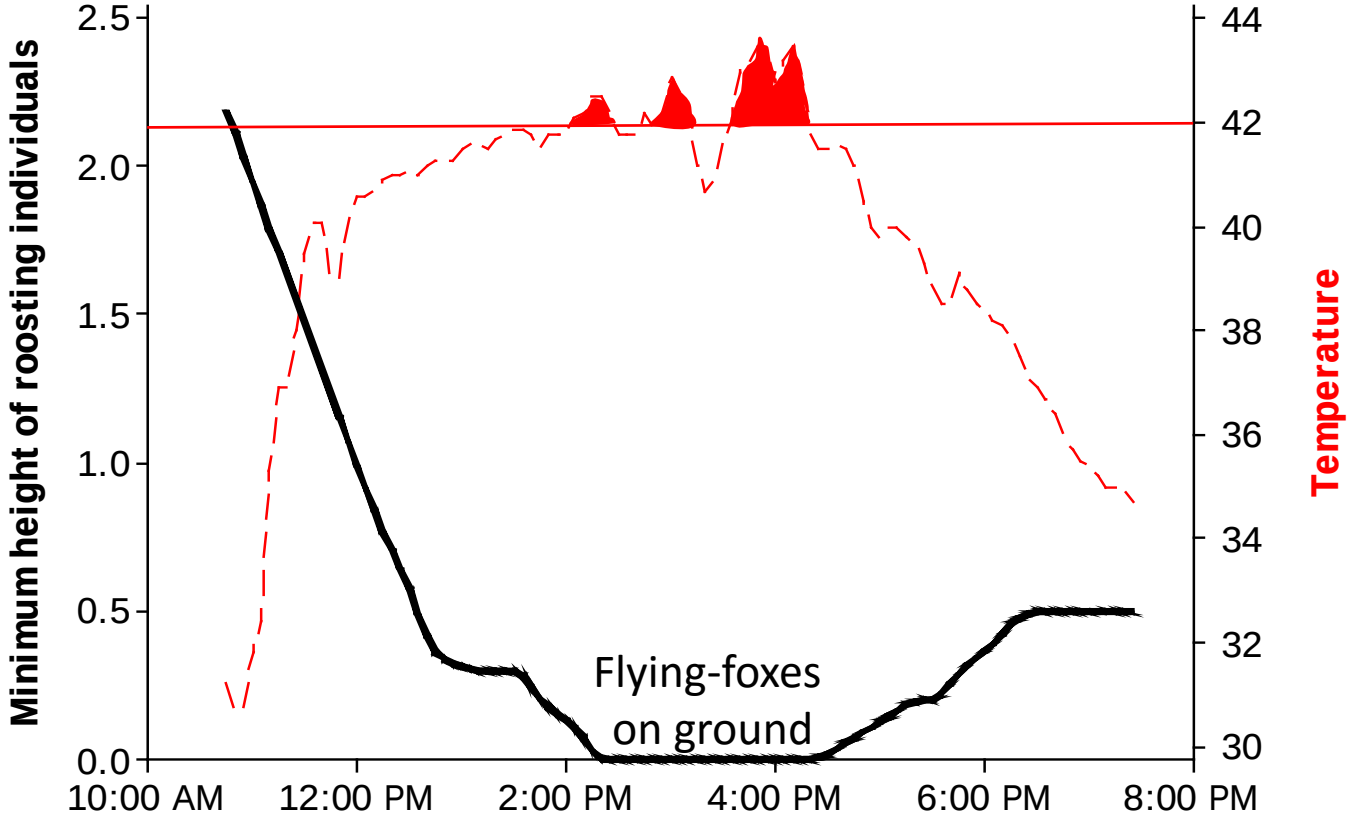




Dalziell & Welbergen, unpublished

Welbergen *et al,* 2008 *Proc Roy Soc B,* 275, 419-425

Beyond 42°C, thermoregulatory mechanisms become overwhelmed



Dalziell & Welbergen, unpublished

Welbergen *et al,* 2008 *Proc Roy Soc B,* 275, 419-425

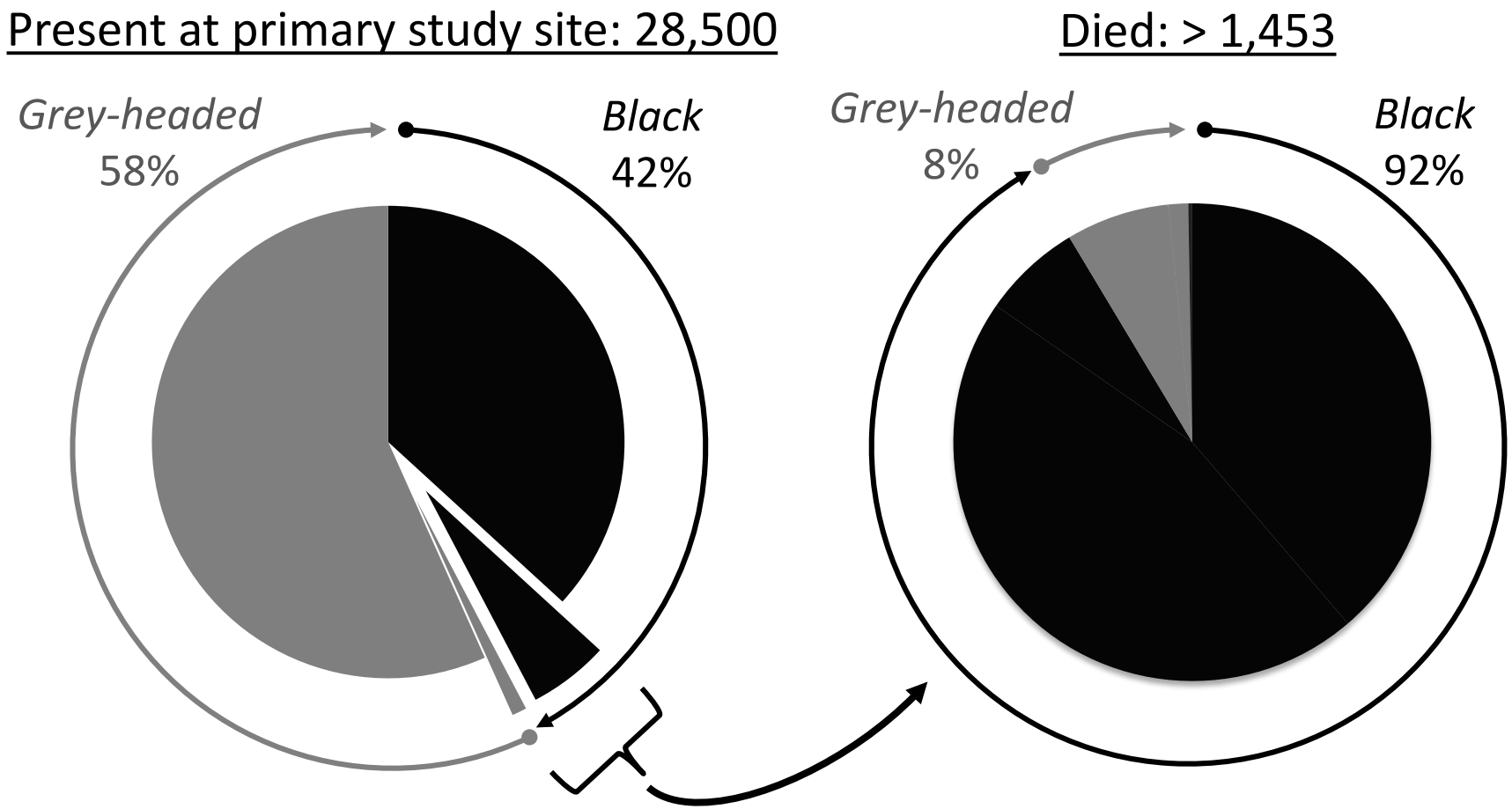
.. and dead bats soon litter the forest floor

Who died?





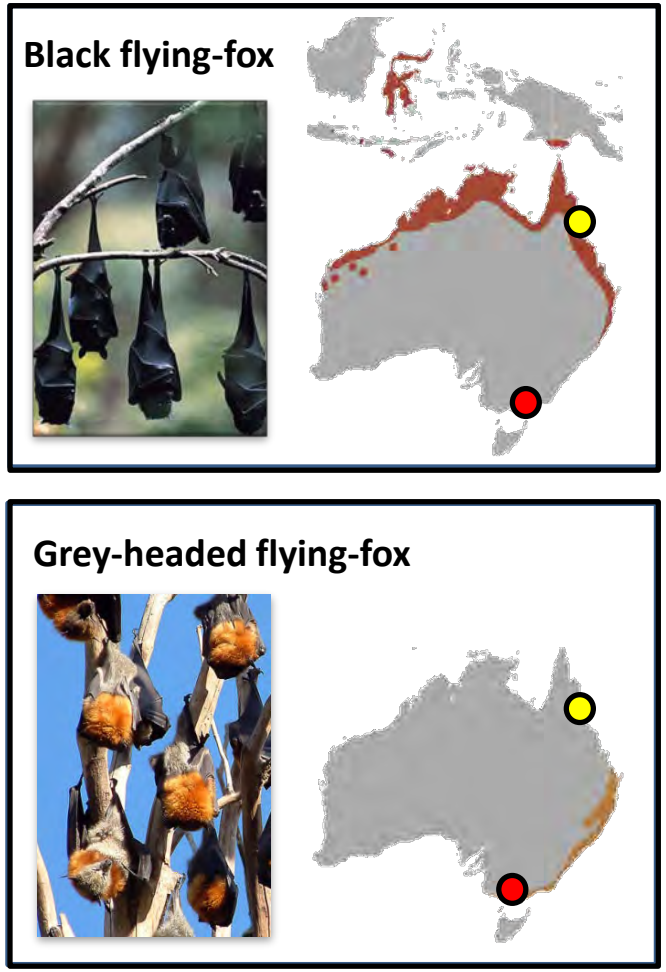

Mortality was higher in the black flying-fox than the grey-headed flying-fox

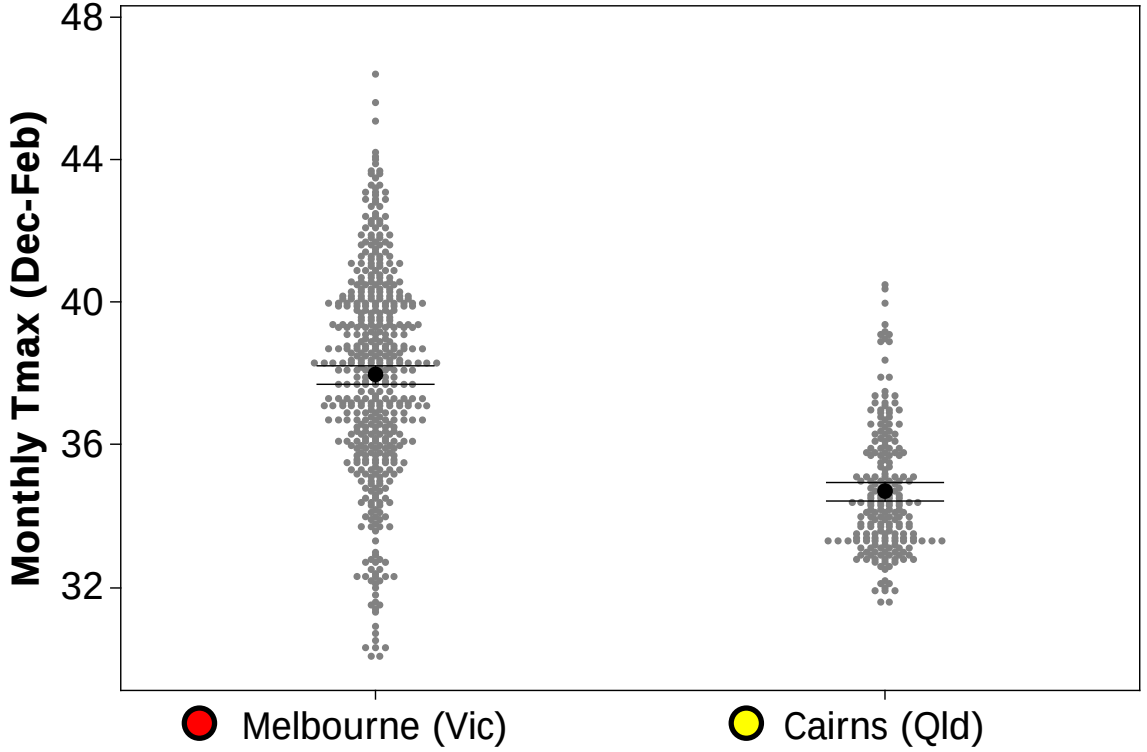


Dallis Park Colony, January 2002

Welbergen *et al,* 2008 *Proc Roy Soc B,* 275, 419-425

Why is mortality higher in the black flying-fox?





- As a more tropical species, the black flying-fox is exposed to *lower* maximum temperatures

Welbergen *et al,* 2008 *Proc Roy Soc B,* 275, 419-425

Mortality was higher among juveniles and mature females

	Grey-headed	Black
Juveniles	5%	49%
Mature females	<1%	15%
Mature males	0%	3%

Dallis Park Colony, January 2002

Welbergen *et al,* 2008 *Proc Roy Soc B,* 275, 419-425

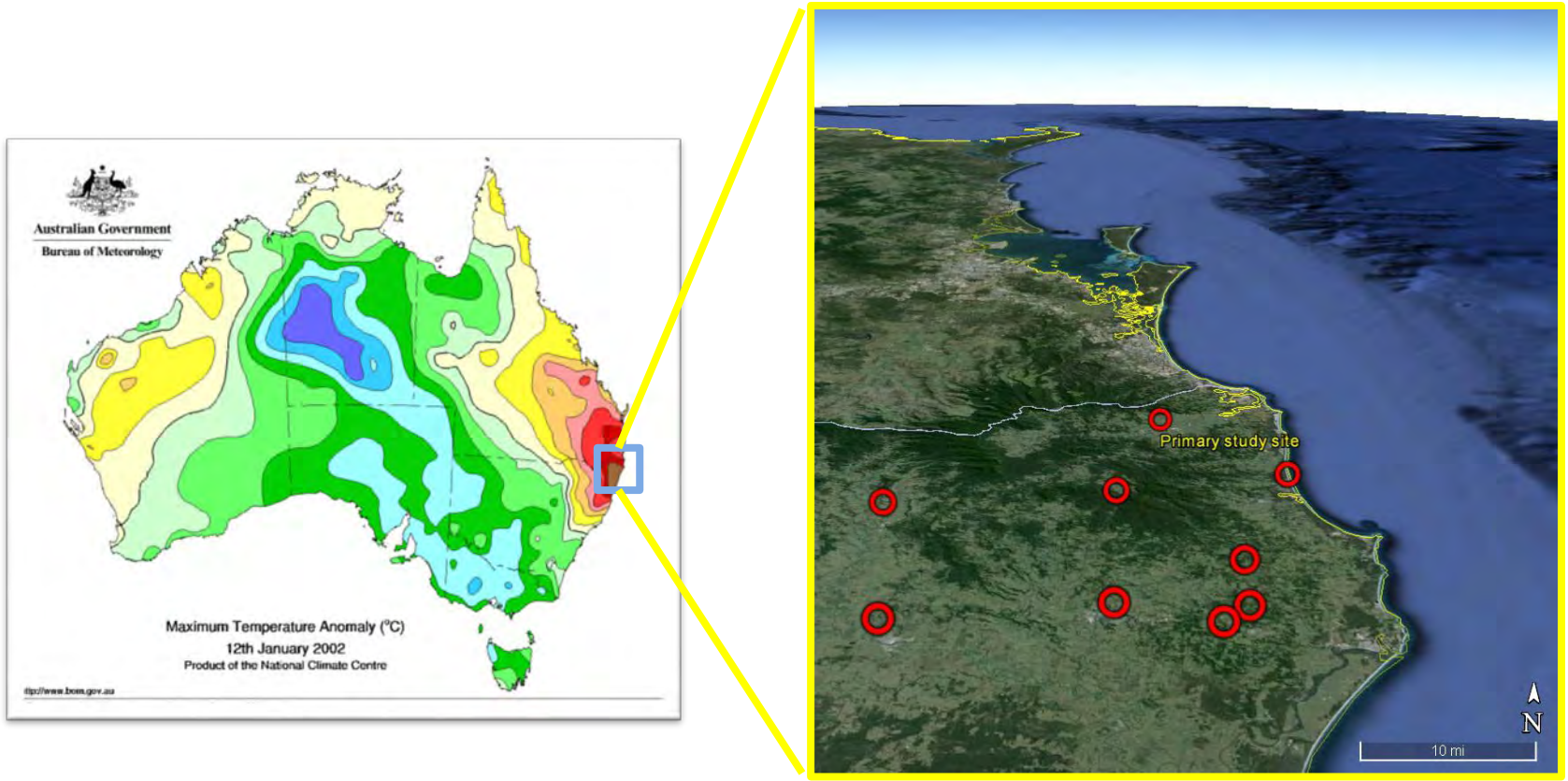
Why is mortality higher among juveniles and mature females?

- Juveniles have a lower thermoregulatory capacity (*Bartholomew et al. 1964*)

- Where assessed, mature females that died were lactating, and lactation increases thermoregulatory needs (*Brody 1974*)

Welbergen *et al,* 2008 *Proc Roy Soc B,* 275, 419-425

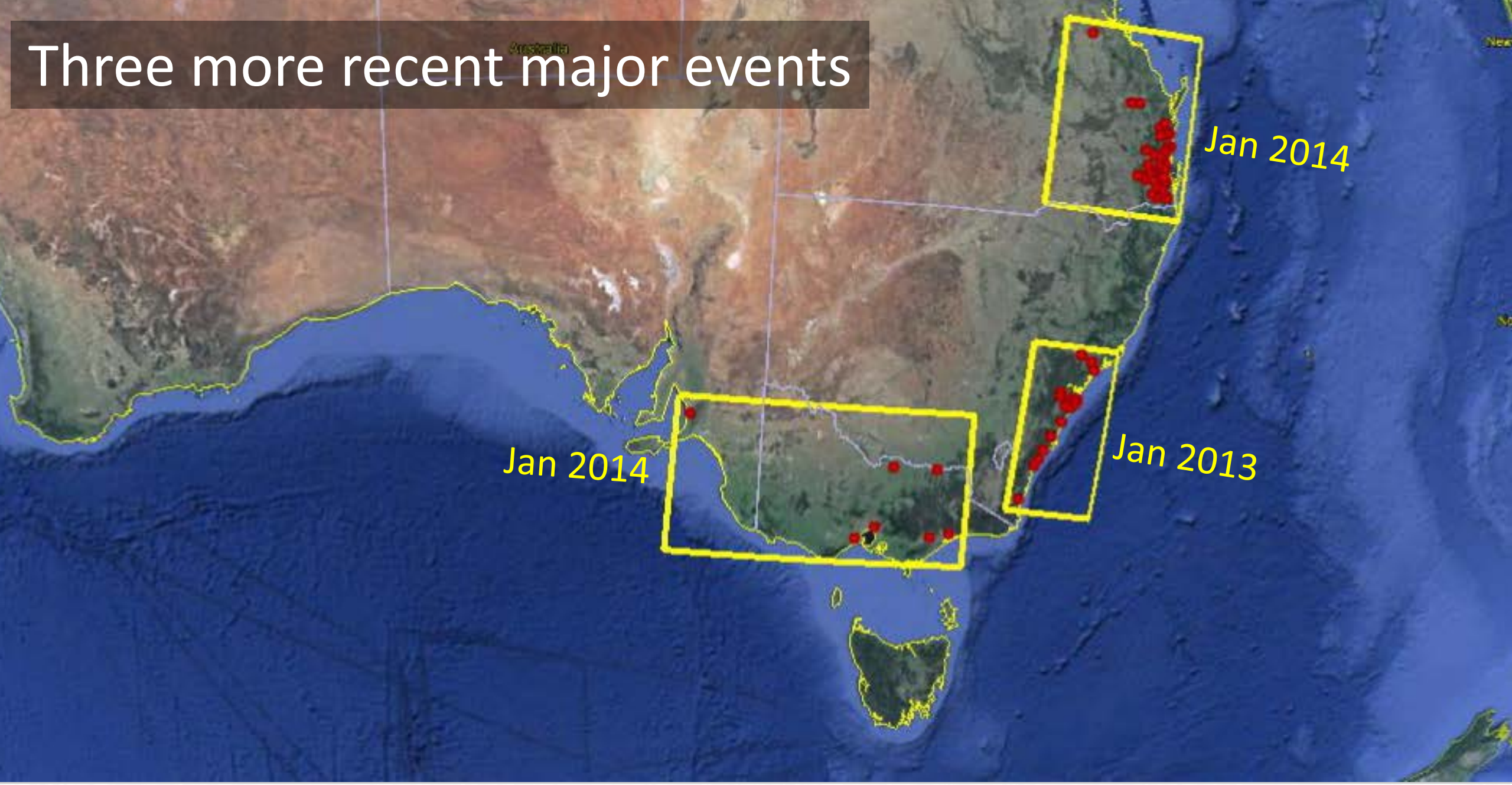
During the January 12th 2002 event, about 4,000 animals died in nine roosts



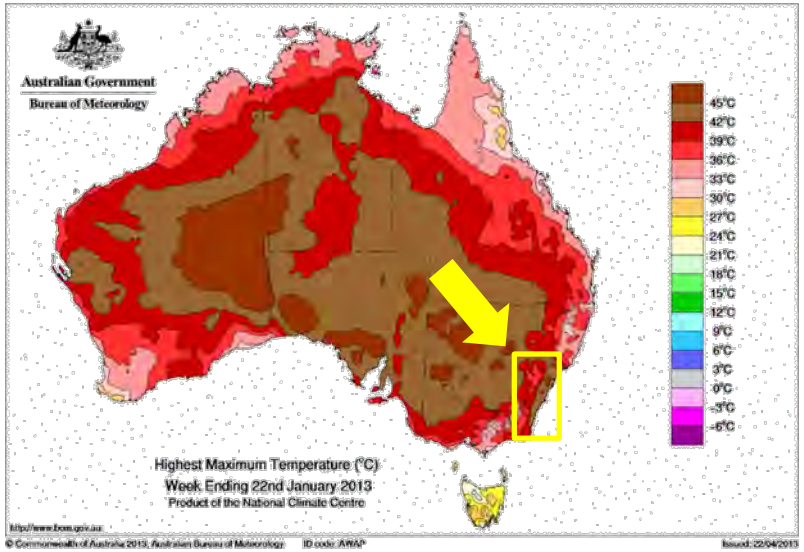
Welbergen *et al,* 2008 *Proc Roy Soc B,* 275, 419-425

Are such events a problem for flying-foxes?

Three more recent major events



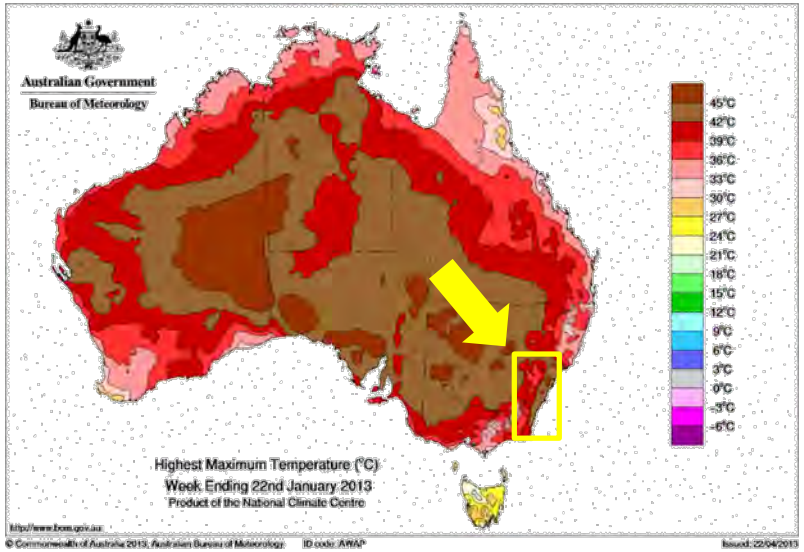
NSW event, January 2013



- 18 colonies affected
- **10,000**+ dead
- Mortality biased towards
  - Black flying-foxes
  - Juveniles
  - Adult females

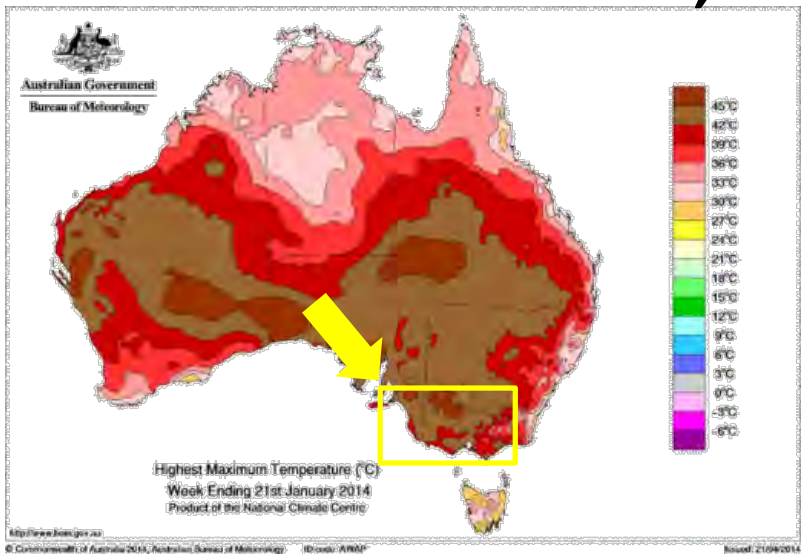
Welbergen *et al*, *unpublished*

NSW event, January 2013



- 18 colonies affected
- **10,000**+ dead
- Mortality biased towards
  - Black flying-foxes
  - Juveniles
  - Adult females

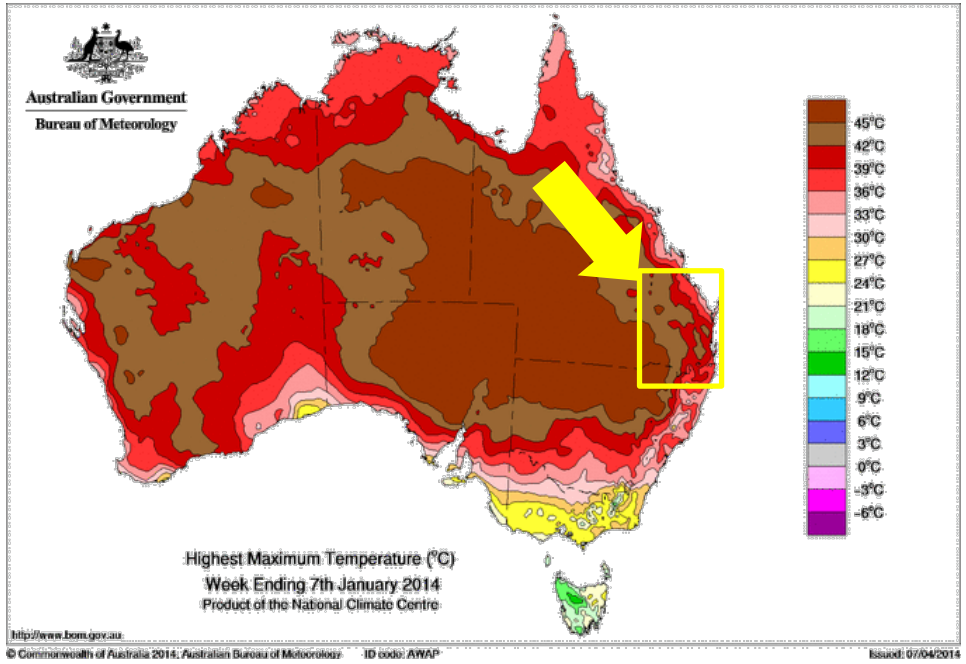
Southern states event, January 2014



- 7 colonies affected
- **4,500**+ dead
- Mortality biased towards
  - Juveniles
  - Adult females

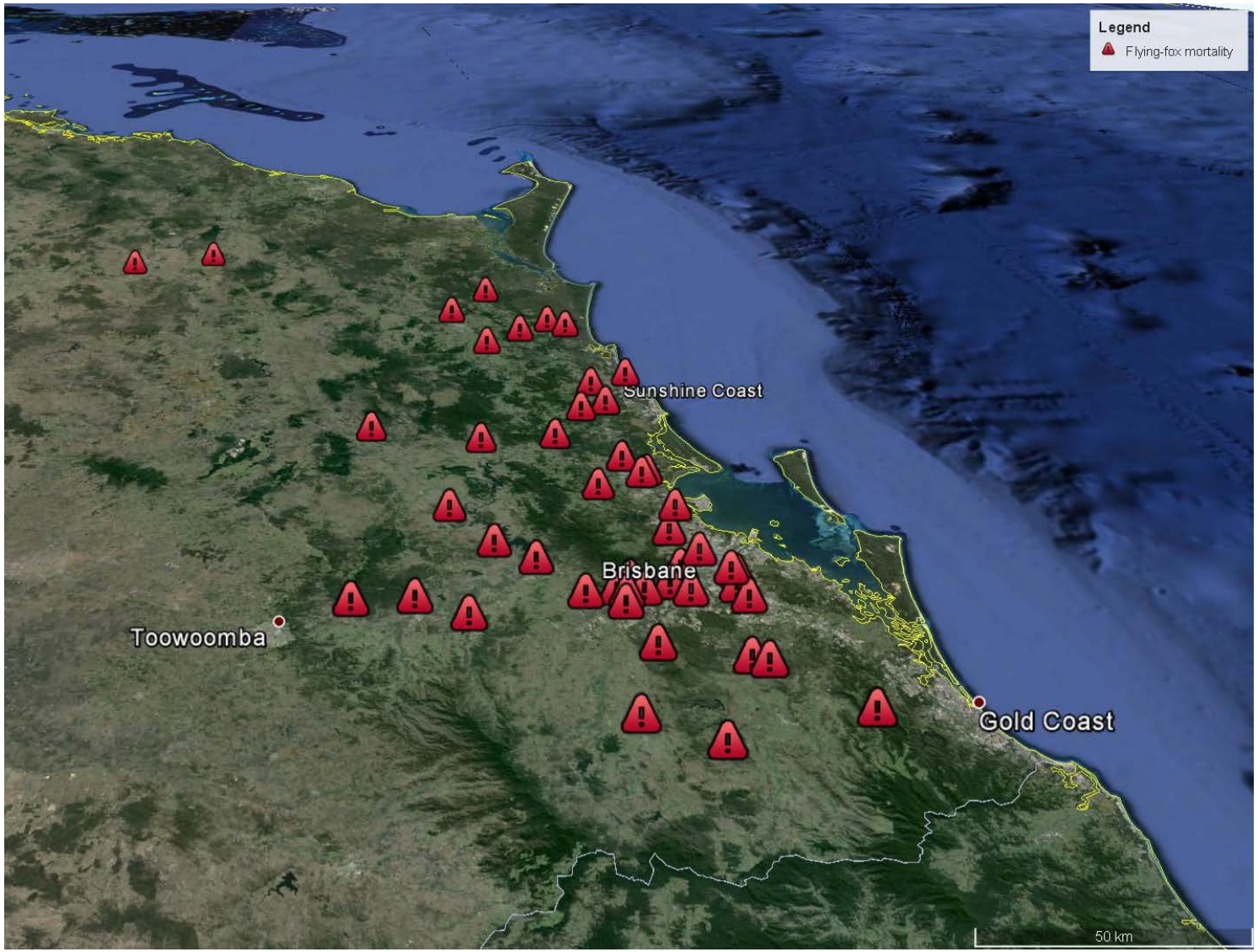
Welbergen *et al*, *unpublished*

SEQ event, January 2014



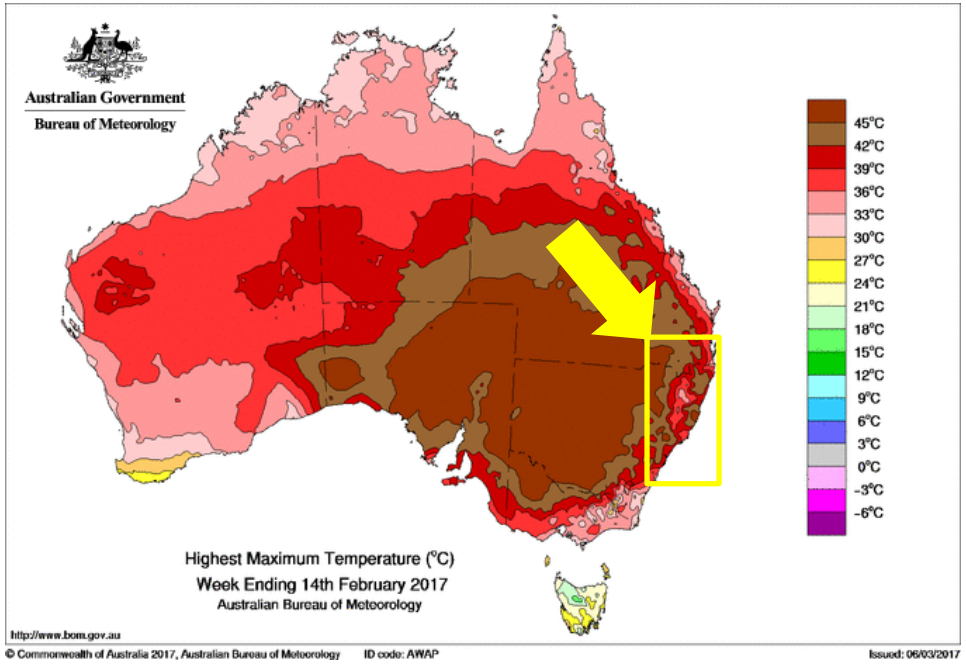
- 52+ colonies affected
- **45,500**+ dead
- Mortality biased towards
  - Black flying-foxes
  - Juveniles
  - Adult females

➢ **~50% OF ALL BLACK FLYING-FOXES DIED!**

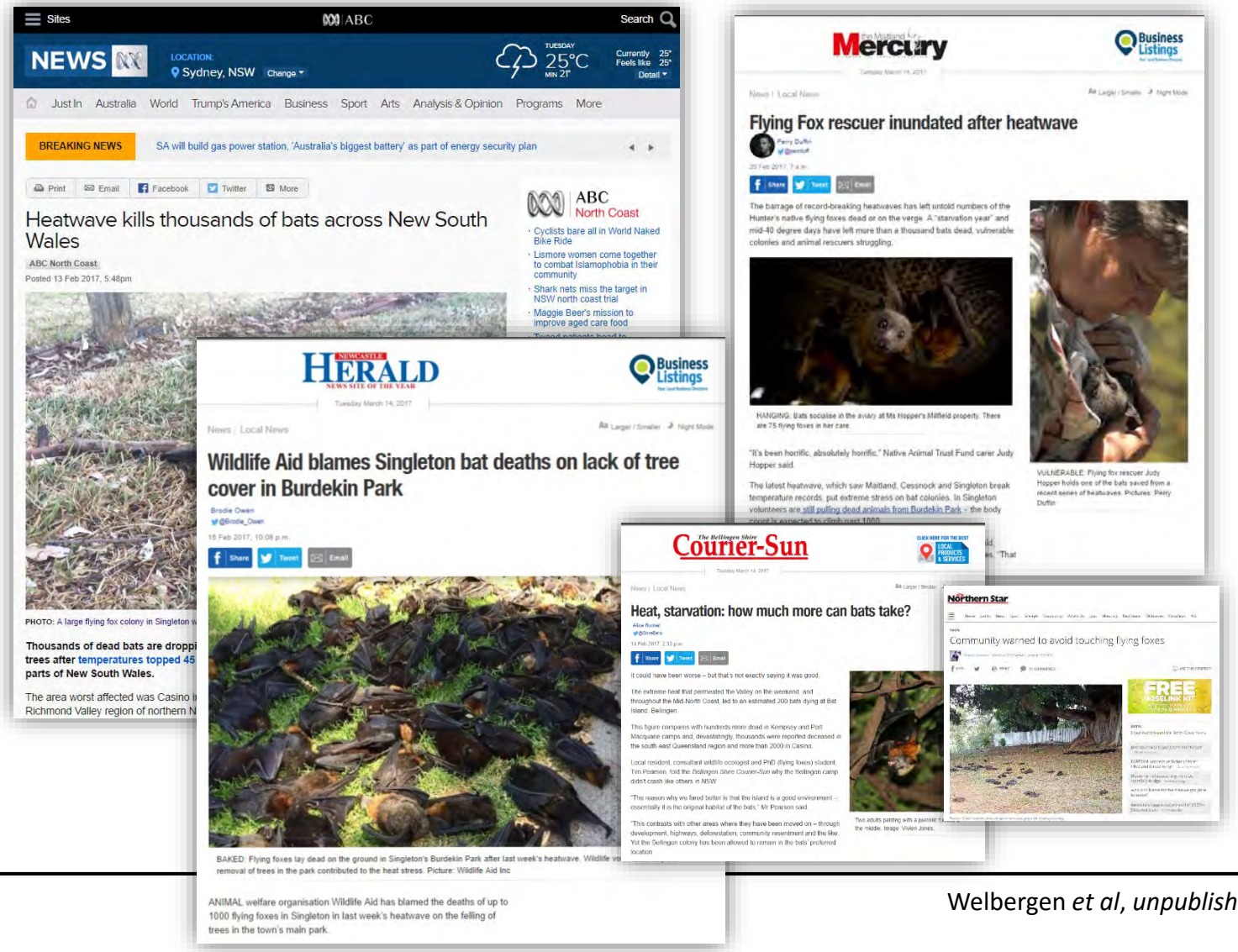


Welbergen & Martin et al, unpublished
Welbergen, Martin, Booth, *The Conversation 24-2-2014*

Another major event: 12-14 February 2017

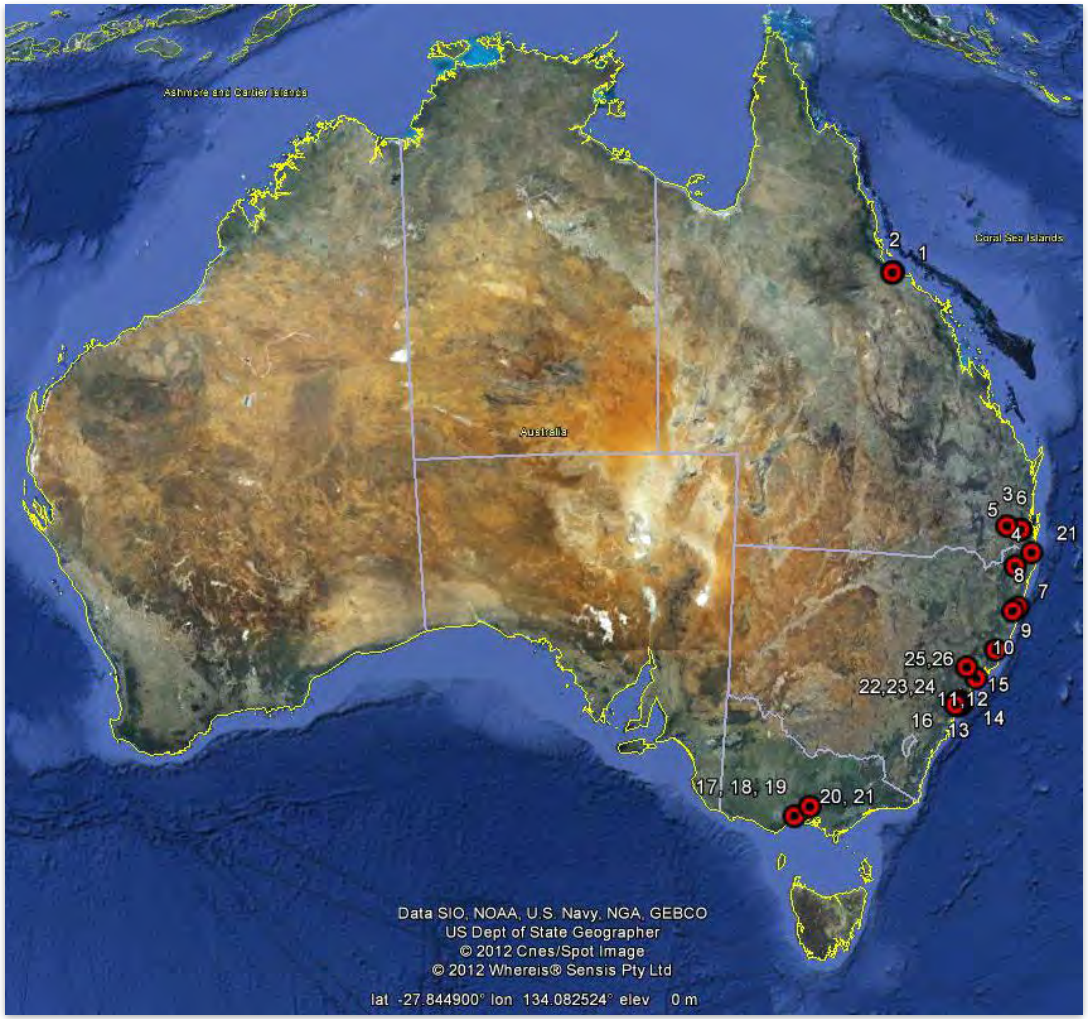


- At least 15 colonies affected
- **10,000**+ dead (and counting..)
- Mortality biased towards
  - Black flying-foxes
  - Juveniles
  - Adult females



Welbergen *et al*, *unpublished*

Are die-offs more common now than in the past?

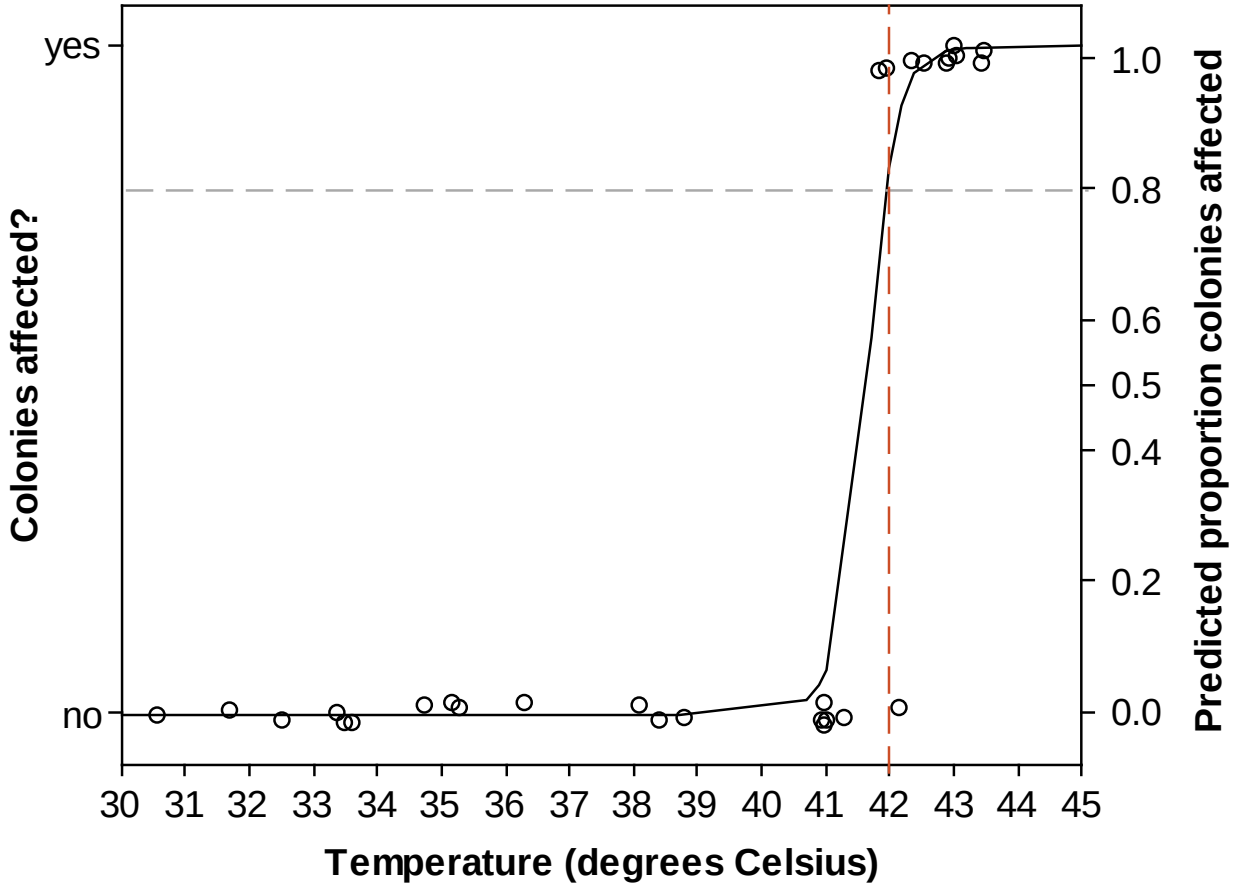


- So far we have found evidence of at least 31 die-off events in Australia
- The earliest recorded die-off dates back to 1791
- 27 die-offs occurred after 1994

Welbergen *et al* 2008 *Proc Roy Soc B,* 275, 419-425
Welbergen *et al, unpublished*

Mortality is strongly associated with T > 42.0°C (107.6°F)

2002 Northern NSW extreme heat event:



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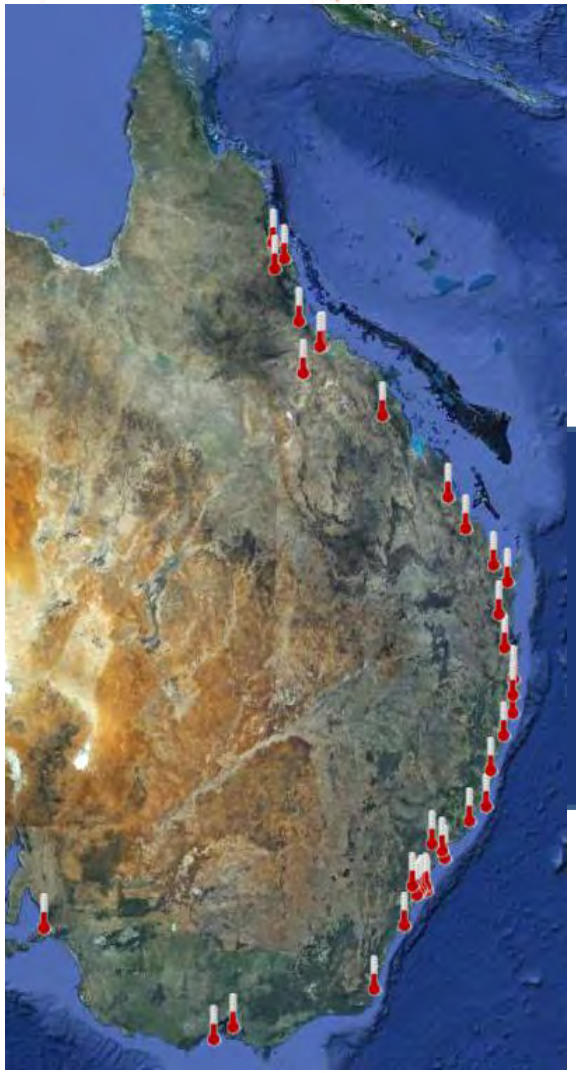
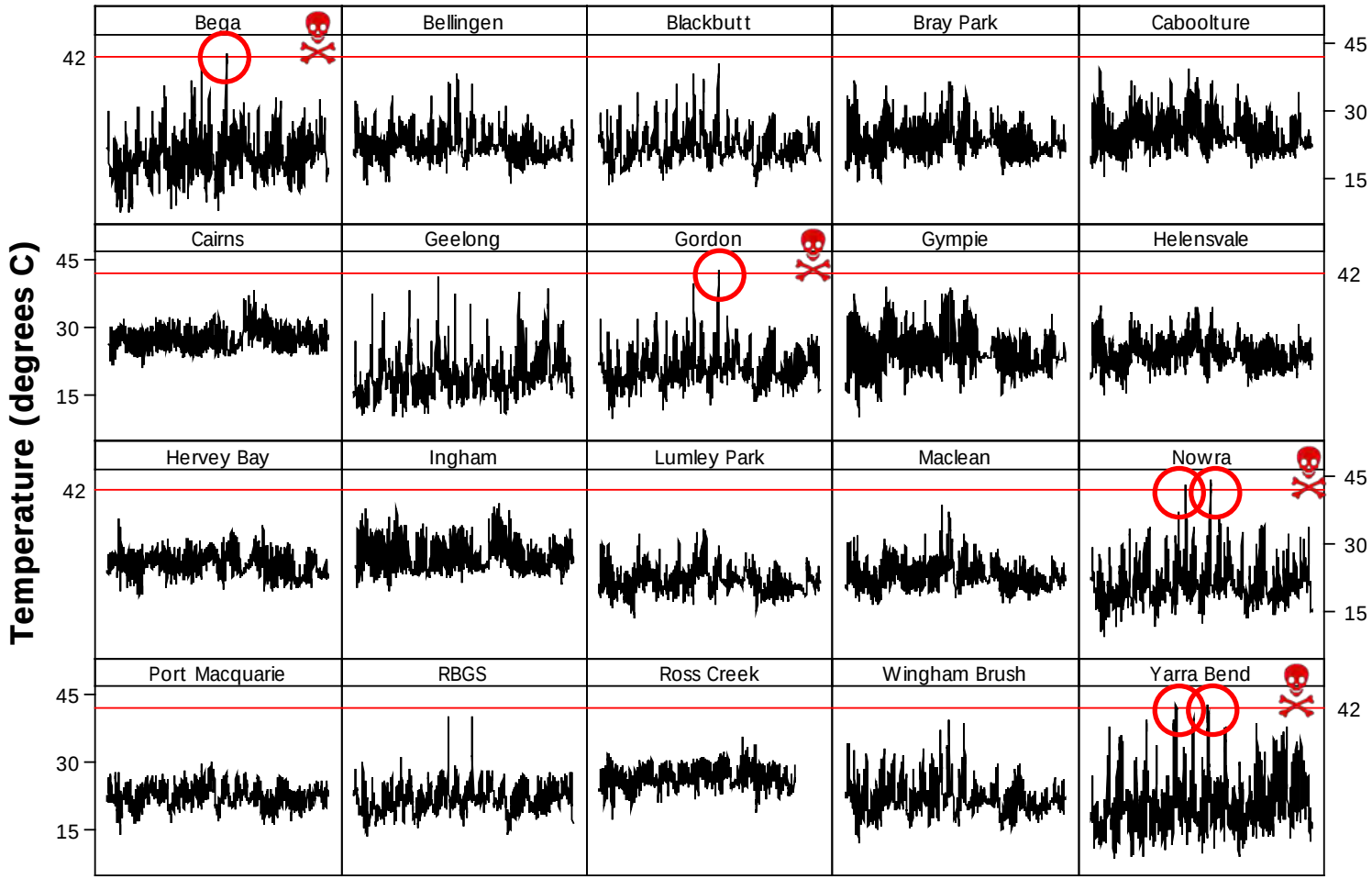
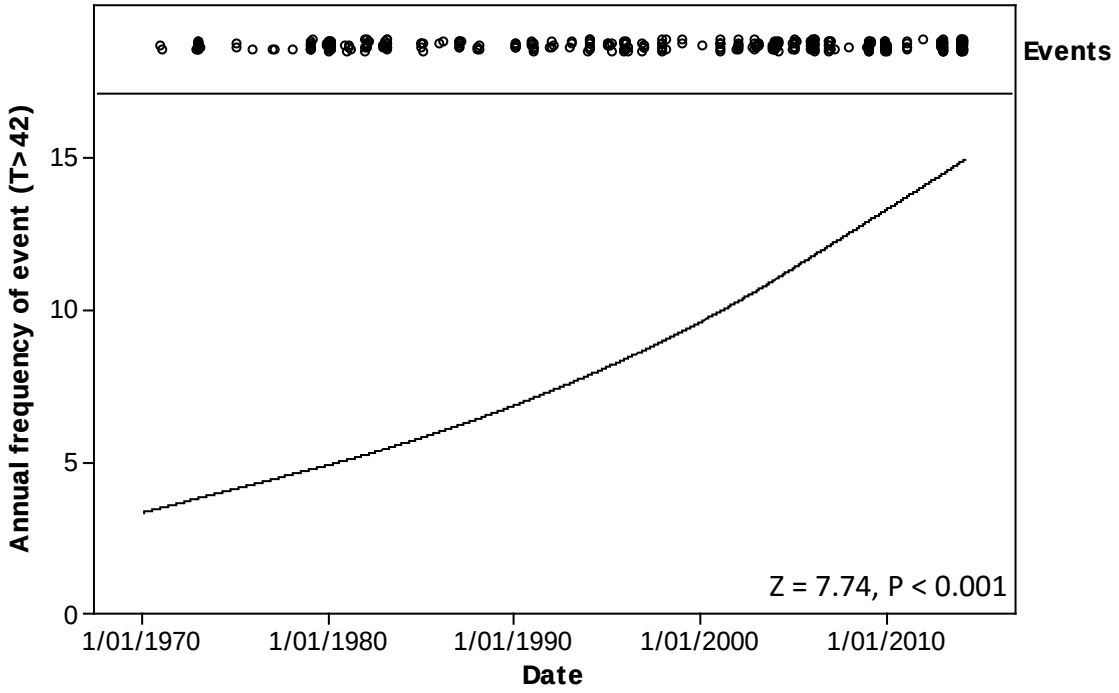




Welbergen *et al, in prep*

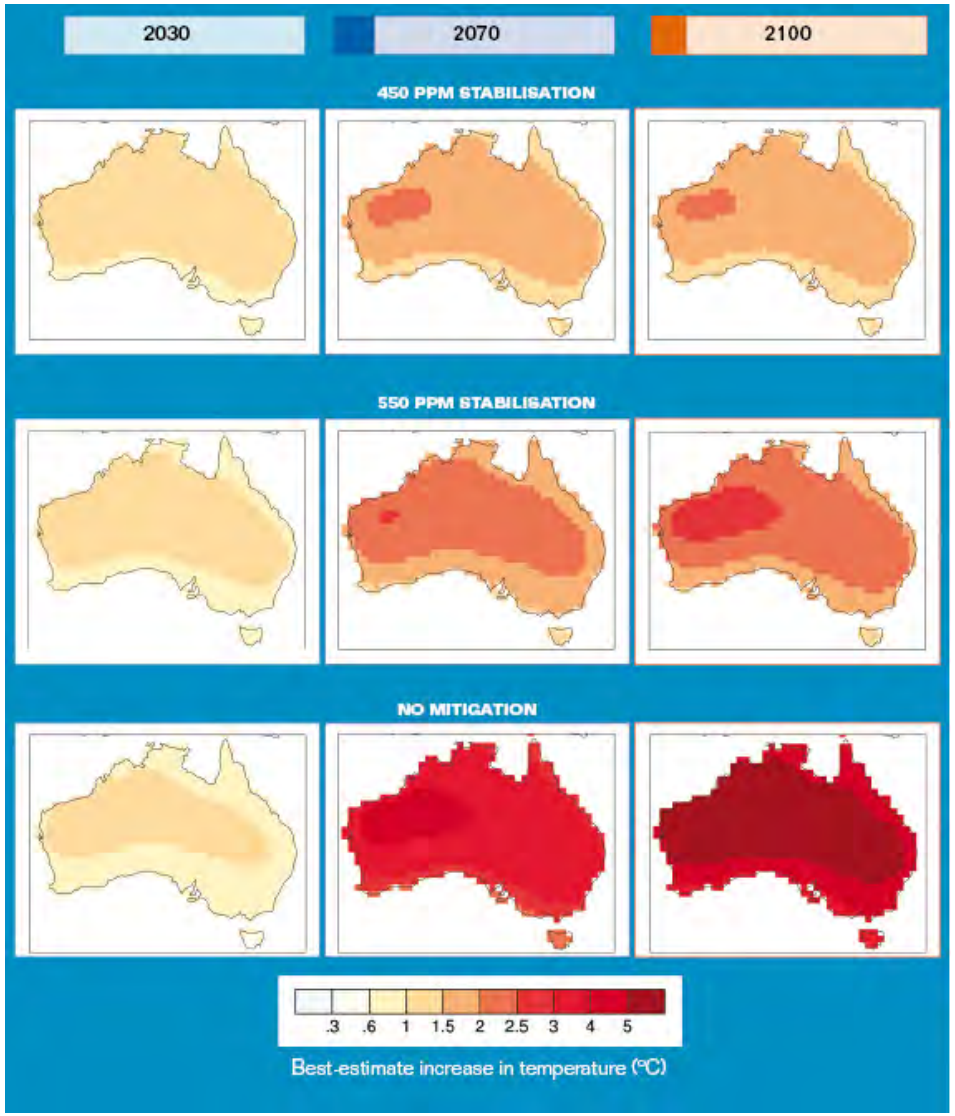
Roost are now more often exposed to T > 42.0°C

- The probability that flying-foxes will encounter > 42°C temperatures has increased almost *three-fold* since the 1970s



Welbergen *et al,* unpublished

Will die-offs become more common in the future?



- There is little doubt that as Australian summers become hotter, die-offs will become more frequent and widespread

- Our current work aims to build a mechanistic understanding of the vulnerability of flying-foxes to such events

The Garnaut Climate Change Review, 2008

Ratnyake et al, in prep

Canaries in the Anthropocene?

- Flying-fox die-offs are particularly conspicuous events
- This raises concern that similar impacts occur in species with more solitary and cryptic lifestyles
- Indeed, heat-related die-offs have been reported in other fauna, including koalas, Carnaby's black cockatoos, budgerigars, bumblebees, butterflies, and humans..

Welbergen *et al, The Conversation 24-2-2014*

Welbergen, 2012 ISBN: 978-84-87790-69-0

Flying-fox die-offs are an important wildlife management issue

- Extreme heat events are a major cause of death for flying-foxes (Tidemann & Nelson 2011)

- They can place enormous demands on land managers and wildlife carers

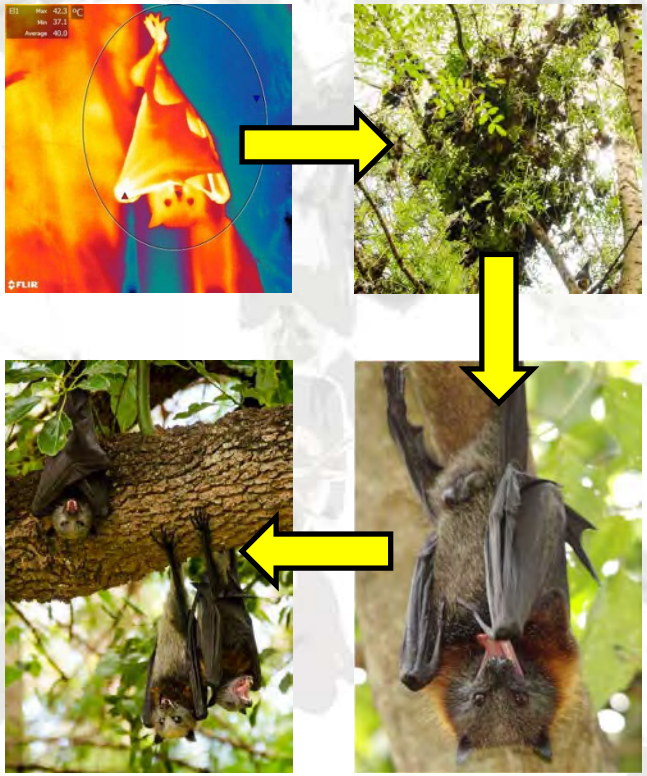
➢ There is an urgent need to streamline management responses!

Welbergen *et al, The Conversation 24-2-2014*
Welbergen, 2012 ISBN: 978-84-87790-69-0

Responding to flying-fox heat stress events

Before

During



After

Responding to flying-fox heat stress events

Before

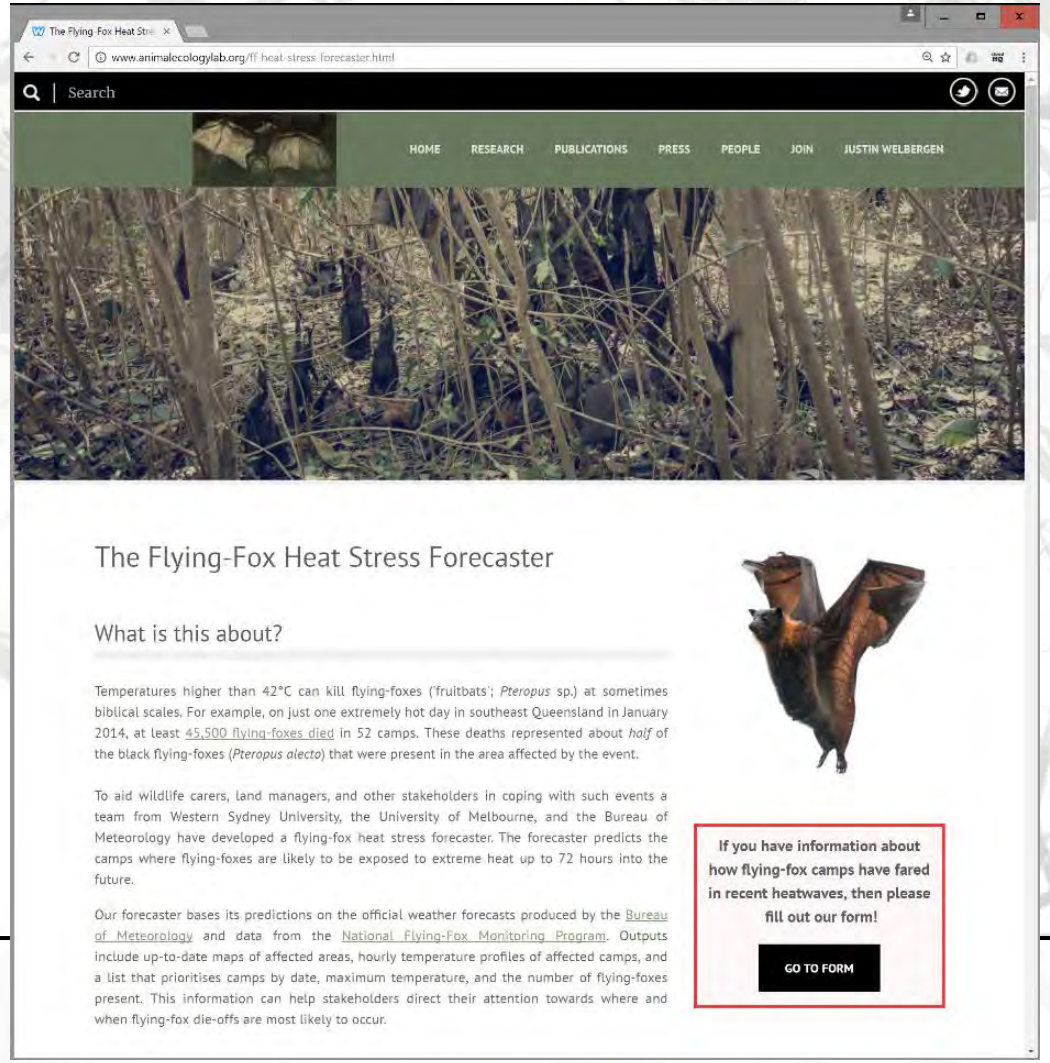
During

After

Before - The flying-fox heat stress forecaster

- Built in collaboration with the University of Melbourne, CSIRO, and the Australian Bureau of Meteorology
- Predicts up to 72 hours into the future where known flying-fox roosts are likely to be exposed to extreme heat (T > 42°C)
- Mortality forecasts have high accuracy (24 hrs = 77%; 48 hrs = 73%, as tested against past mortality data)

www.animalecologylab.org/ff-heat-stress-forecaster



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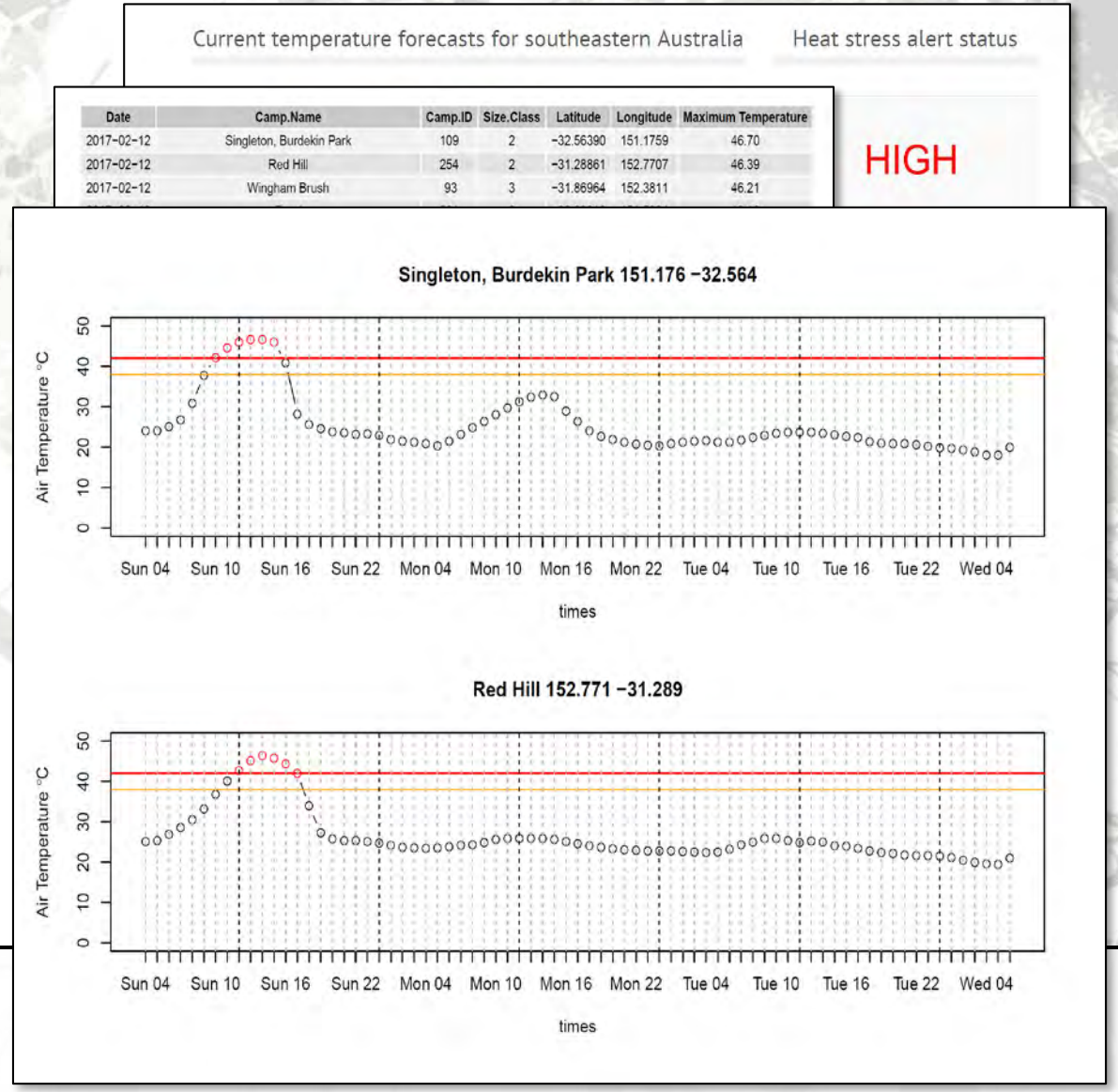
CSIRO

Before - The flying-fox heat stress forecaster

Outputs

- **Maps** of affected areas
- **Lists** of priority colonies (ranked by date, temperature, size)
- **Temperature profiles** of priority colonies

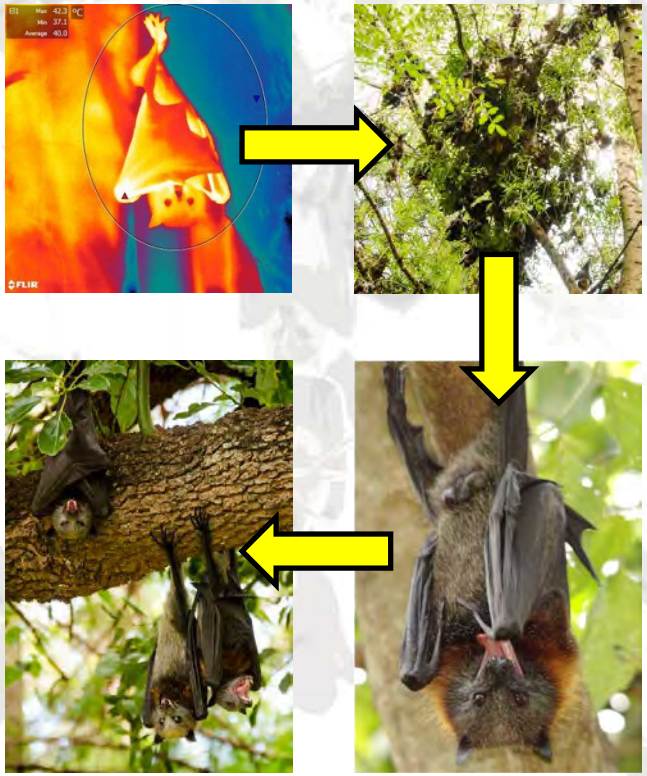
➢ Outputs help direct wildlife carers, land managers, and health officials towards where and when flying-fox die-offs are likely to occur



Responding to flying-fox heat stress events

Before

During



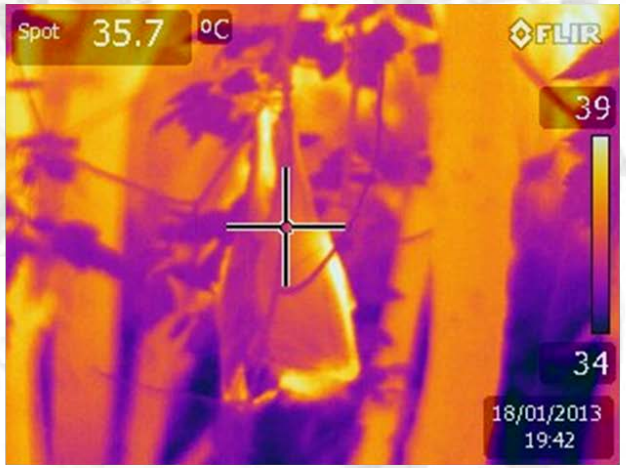
After

During - spraying

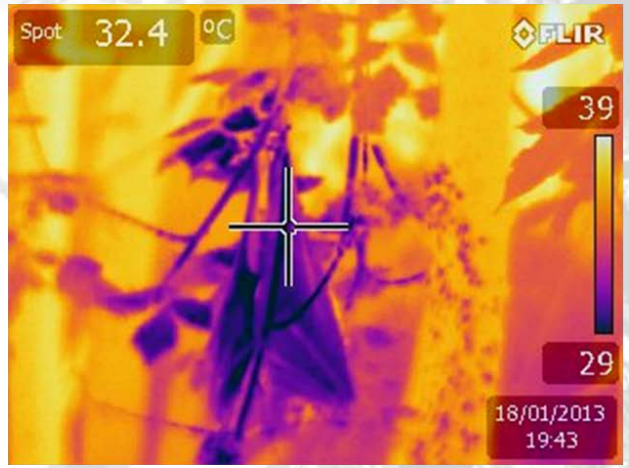
- Spraying of individuals by hand can cool highly distressed animals

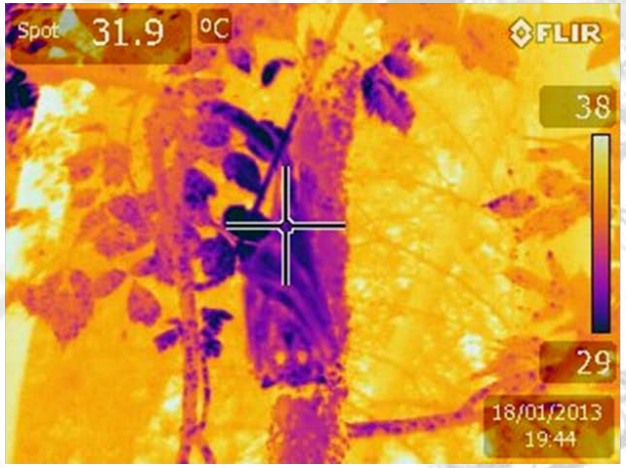
- But can disturb other bats!

Before spraying



After spraying



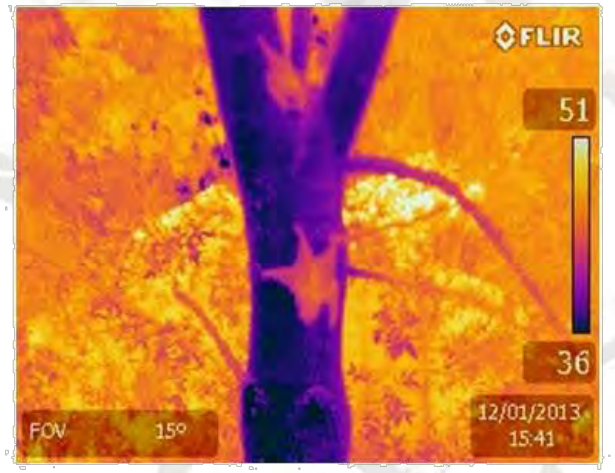


During - wholesale misting of camps

- Decreases temperature but raises humidity, which risks a *net increase* in heat stress for the bats
- Effectiveness not proven at present
- Can disturb bats!

During – disturbing heat-stressed individuals

- Entering a camp may lead to increased mortality when animals are forced to leave their cooler microhabitats



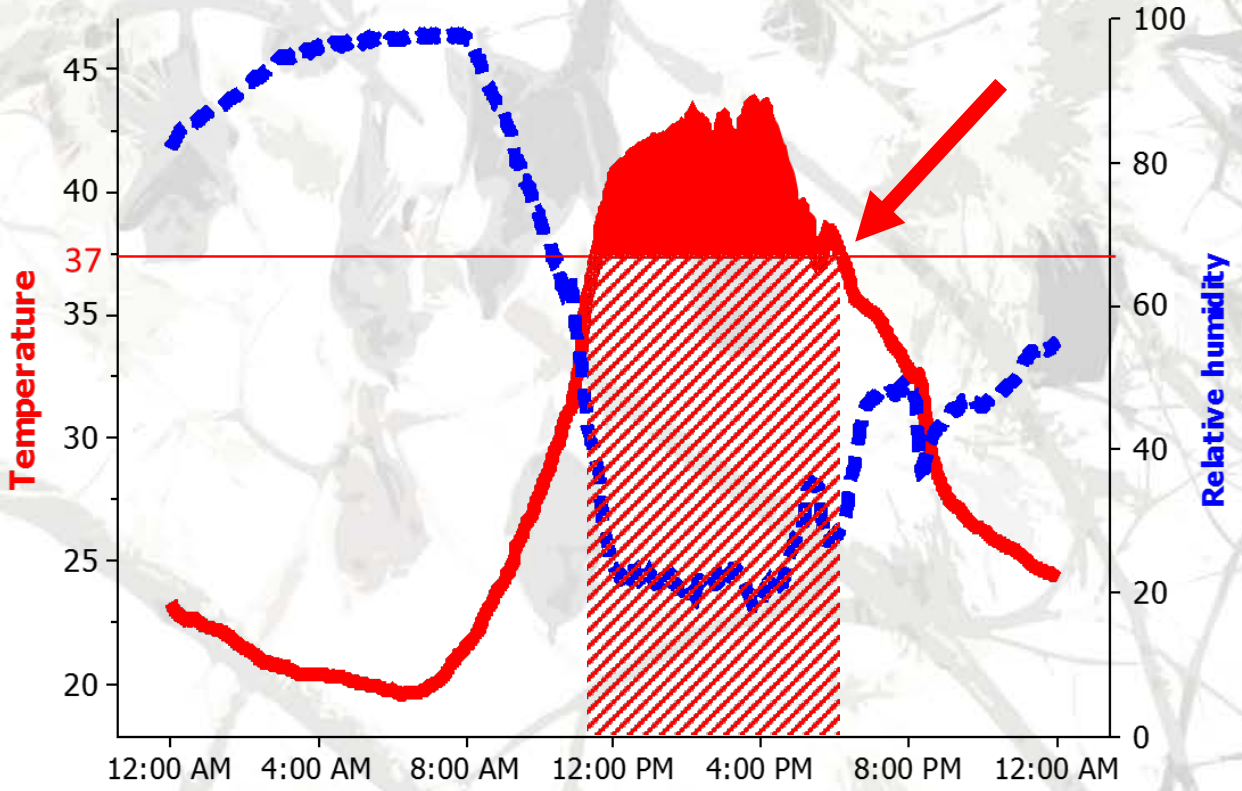
During - removing animals from a camp

- Many animals will recover without intervention..

All heat stressed individuals in this cluster of young survived 47^{o} C

During - removing animals from a camp

- Therefore, intervention is generally not recommended, unless animals are still unresponsive after temperatures have dropped below ~37°C.



Responding to flying-fox heat stress events

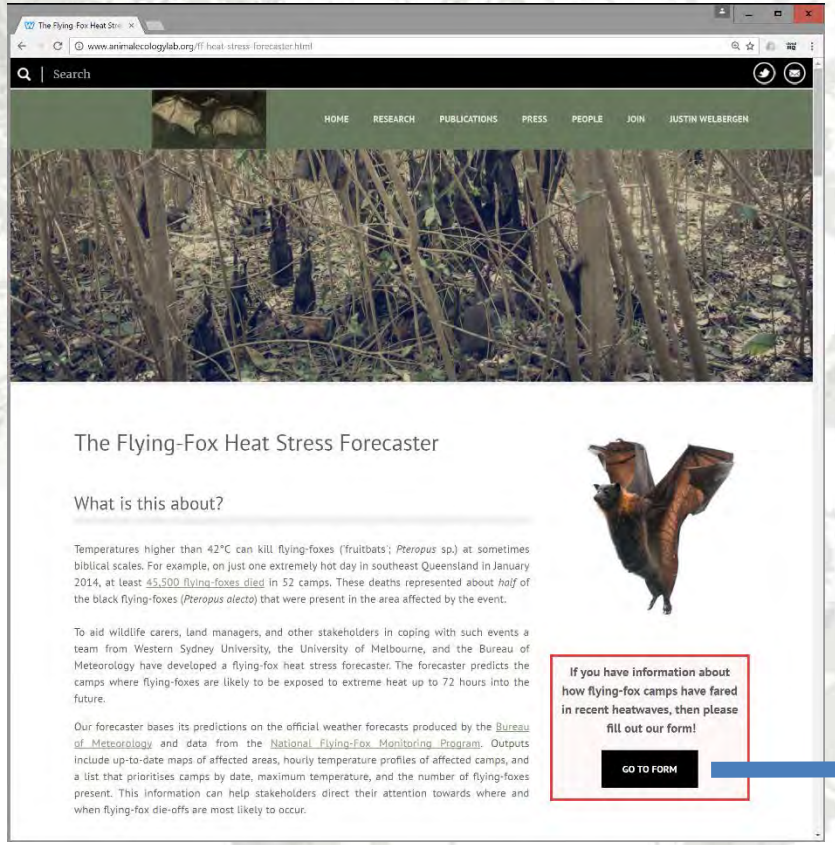
Before

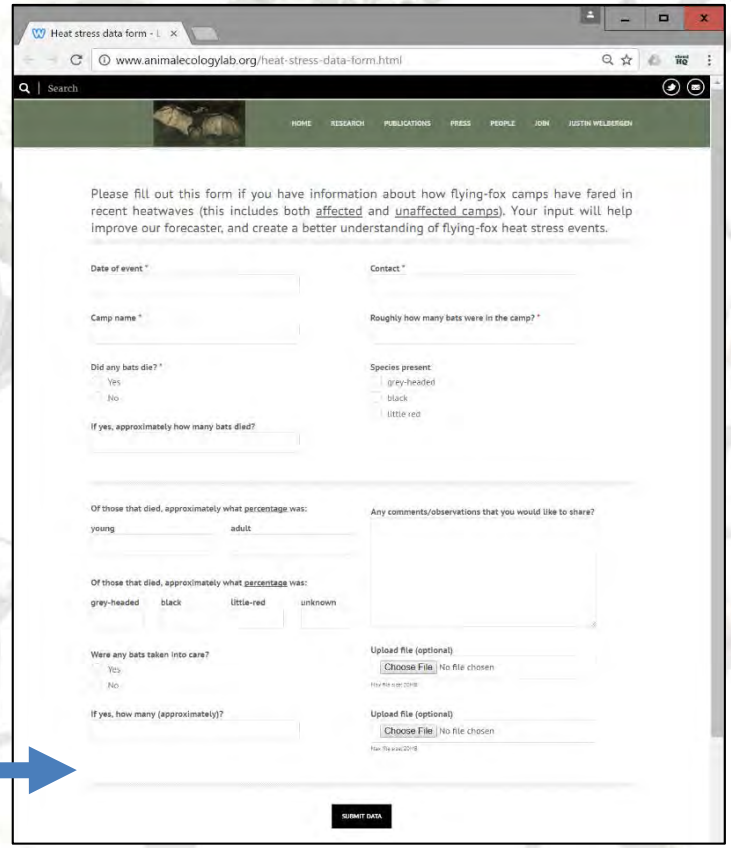
During

After

After – data collection

www.animalecologylab.org/ff-heat-stress-forecaster





Citizen Science Data:

- Contributes to more effective management
- Improves the heat stress forecaster
- Helps create a better understanding of the long-term impacts on flying-foxes

ANIMALECOLOGYLAB.ORG
WESTERN SYDNEY UNIVERSITY
Hawkesbury Institute for the Environment
THE UNIVERSITY OF MELBOURNE
Australian Government Bureau of Meteorology
CSIRO

After – disposal of bodies

- Dead bodies should quickly be collected by ABLV vaccinated people and with appropriate PPE
- Carcasses can be dropped at registered landfill sites

http://www.environment.nsw.gov.au/animals/flying-fox-heat.htm
http://www.health.nsw.gov.au/infectious/factsheets/pages/rabies-australian-bat-lyssavirus-infection.aspx

THANK YOU!

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