A decade of post-construction bird and bat monitoring at south-eastern Australian wind farms

Elizabeth Stark & Stuart Muir (Symbolix)

Wind & wildlife research meeting, Nov-Dec 2020

data science
AS A SERVICE

Symbolix est. 2004

Wind and wildlife work since 2004

Pre-construction risk analysis
Collision risk models
Post construction monitoring design
Mortality estimation
Spatial tracking and camera analysis

data science
SUPPORT CREW

Motivation

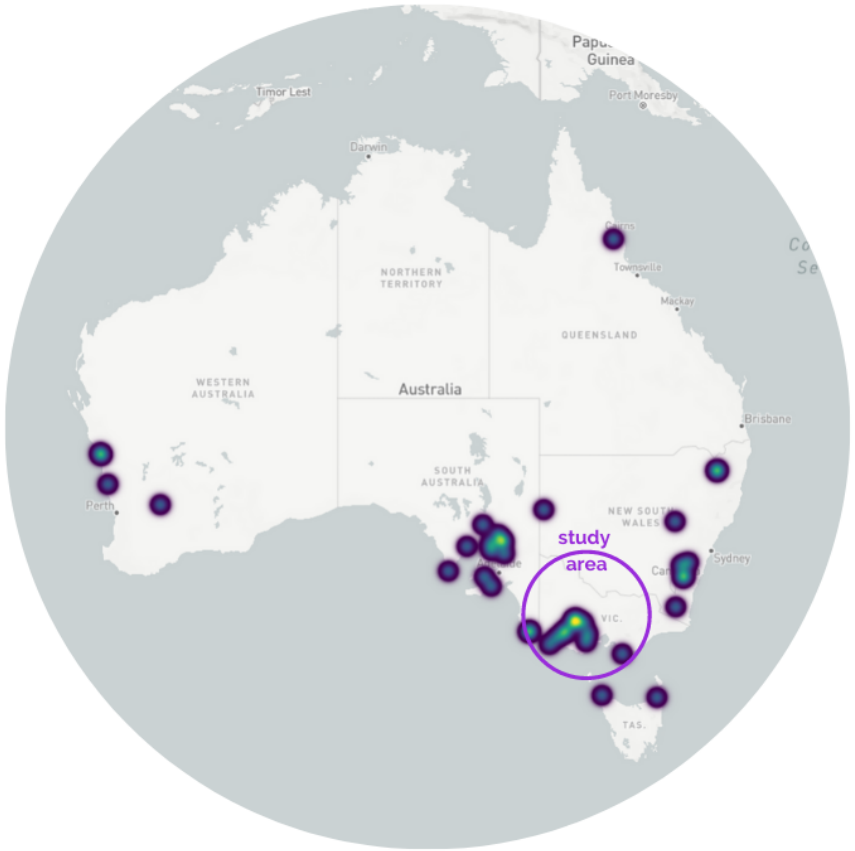
- Create a **combined** post-construction mortality data set, from multiple wind farm sites in Victoria (south-eastern Australia)
- Understand collision risks that turbines pose to bats and birds

Ed Dunens 2015

Three aims

1. Identify species most commonly represented in mortalities in the study area
2. Generate reference values for scavenger loss and searcher efficiency
3. Total annual mortality by species group and turbine class

TUBS 2011



Study area

10 Sites - 764 turbines

Common study design

- **Searcher efficiency trials** estimate success rate of a survey team at finding carcasses
- **Scavenge rate trials** to estimate the time taken for all evidence of a carcass to be lost (mainly through scavenge) at a site.
- **Carcass searches** of the ground adjacent to turbines, out to a specified radius.
  - All bird and bat carcasses (including feather spots and partial remains) are recorded and assumed to be due to turbine collisions.
  - These searches are systematic and repeated at a known interval;
  - surveys commonly occur monthly, and often a pulsed survey is also performed where a repeat search is carried out a few days later.

- **Estimates of total mortality**
  - component surveys are analysed
  - a statistical expansion algorithm is applied to estimate annual mortalities.

BUT

Protocols, data standards and survey timing etc varies from site to site

Methods

Analysis Pipeline

Data collation & synthesis

Cleaned /audited survey data
Common taxa names
Combined into common table structure

Exploratory analysis - set up definitions species/turbine size groups, check for significant differences in site data.

Create 'meta' site

Grouped turbines using 'fall zone' (Hull & Muir 2010)
Combined sites onto common timeline for analysis

Scavenger loss rate

Survival analysis
- fit and choose distributions
- estimate time to loss

Searcher efficiency

Binomial GLM models
- fit and finalise models
- estimate searcher efficiency for humans/dogs for different species size classes
- Assumed ' one-shot' (no repeat searches in data)

Mortality estimate

Monte carlo method to solve

$$\hat{M}_{ij} \cong \frac{C_{ij}}{(\hat{g}_{ij})} \quad (1)$$

where

- $\hat{M}_{ij}$ is the estimated mortalities at turbine i during search j
- C_{ij} is the number of carcasses found
- $\hat{g}_{ij}$ is the estimate of the detection probability for that search and turbine

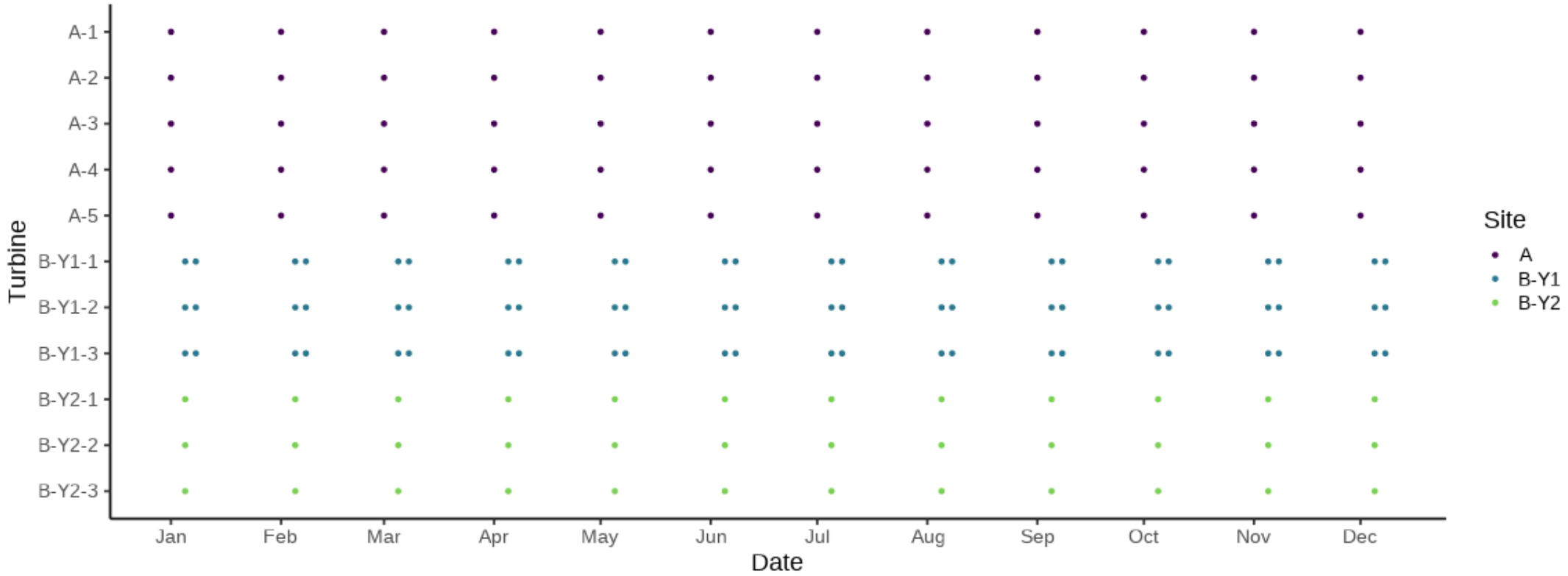
For a given turbine, $\hat{g}_{ij}$ is a function of

$$\hat{g}_{ij} \cong a_i r_{ij} p_{ij} \quad (2)$$

- a_i is the fraction of total carcasses within the searched area (note this is *not* the same as the fraction of area searched)
- r_{ij} is the fraction of the carcasses that arrived at turbine i but have not been lost to scavenge or decay before search j
- p_{ij} is the probability that an existing carcass will be detected by the searcher

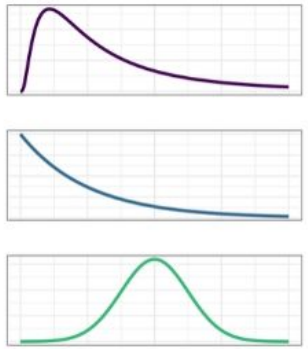
Creating a "meta-site"

- Standardise operating and survey dates
- Treat multi-year sites as replicates of single years
- Combine multiple sites and years into **meta-site**



Mortality estimation

Inputs

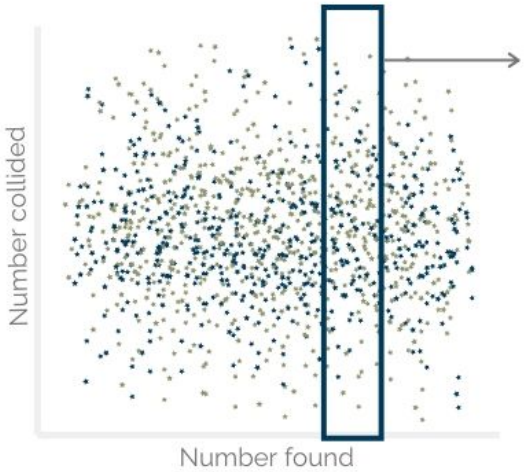


Fit models to estimate:

- scavenge loss
- searcher efficiency
- fall zone

Assume number of collisions has constant probability

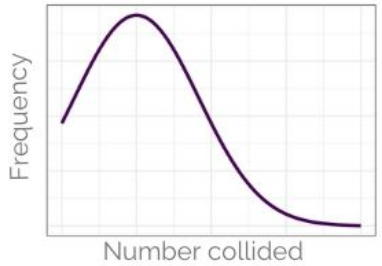
Monte Carlo simulation



We sample from the inputs and simulate the survey protocol

For each simulation we calculate the number found

Estimate



Extract the actual number found and report the distribution of collisions from the simulation

Key results

1. Identify species most commonly represented in mortalities in the study area

Data

Sites	Human surveys	Canine surveys	Total surveys	Hectares searched
10	2059	3373	5432	14746

Uncorrected find totals and rates:

Bats	Birds	Surveys/find	Ha/find
428	355	6.9	19

Note: one **survey** is defined as a single search of one turbine in this table

Most common species in study data:

- 13 species of bat
- 40 species of bird

- 11 bats and 45 birds were unidentified.
- 35 species were found at only one or two sites.

White-striped Freetail Bat
(Austronomus australis):
299 found at 10 sites

Gould's Wattled Bat
(Chalinolobus gouldii):
77 found at 8 sites

Australian Magpie
(Gymnorhina tibicen):
69 found at 10 sites

Southern Bent-wing Bat
(Miniopterus orianae bassanii):
8 found at <3 sites
(critically endangered)

Nankeen Kestrel
(Falco cenchroides):
41 found at 8 sites

Wedge-tailed Eagle
(Aquila audax):
33 at 7 sites

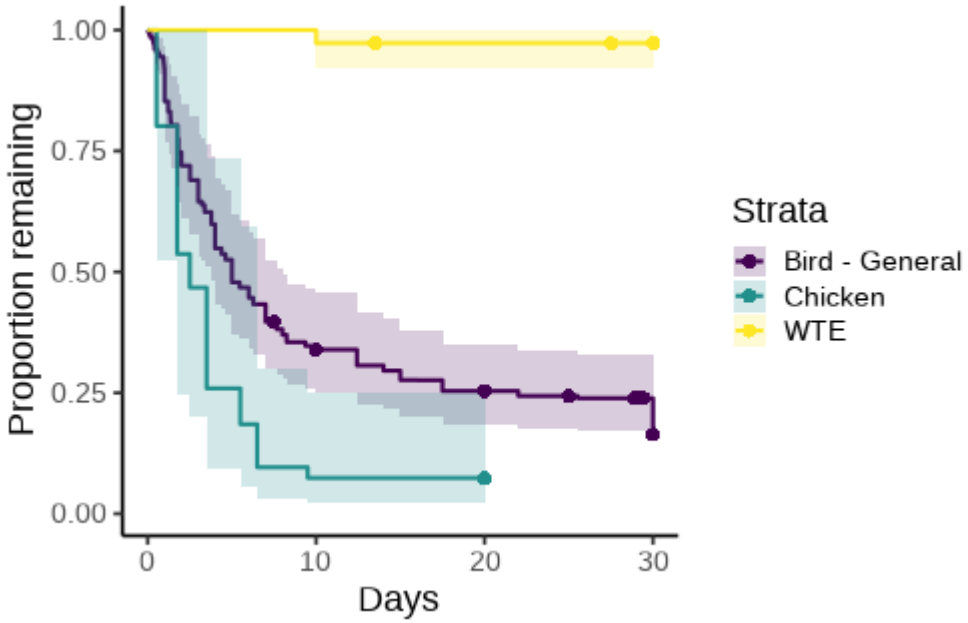
Photos via wikimedia commons:
- White-striped Freetail Bat - Phillip A. Robson
- Gould's Wattled Bat - BKCW8
- Magpie - John O'Neill
- Nankeen Kestrel & Wedge-tailed Eagle - JJ Harrison
- Southern BW Bat - Steve Bourne

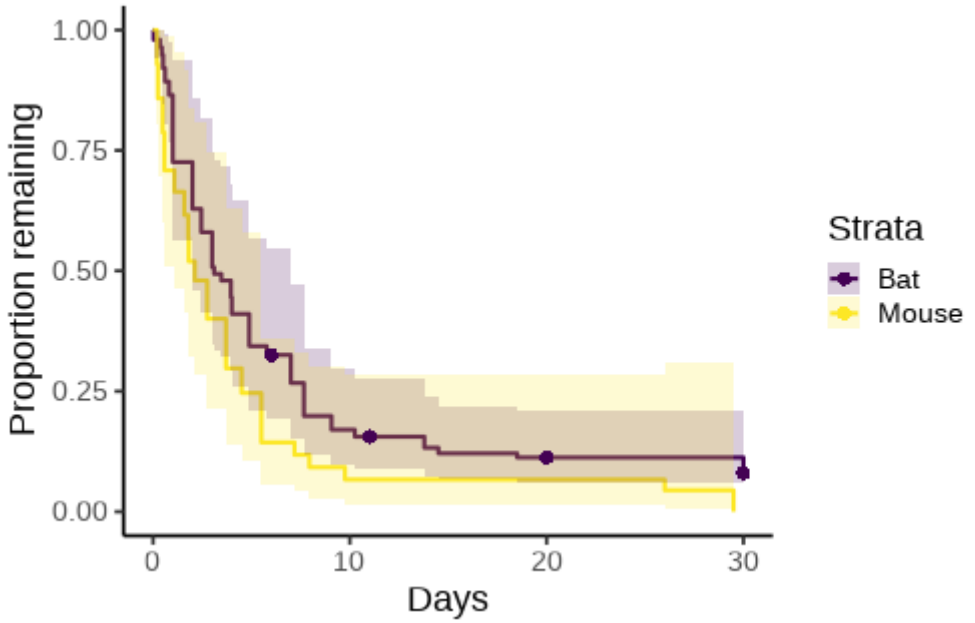
Key results

2. Generate reference values for scavenger loss and searcher efficiency

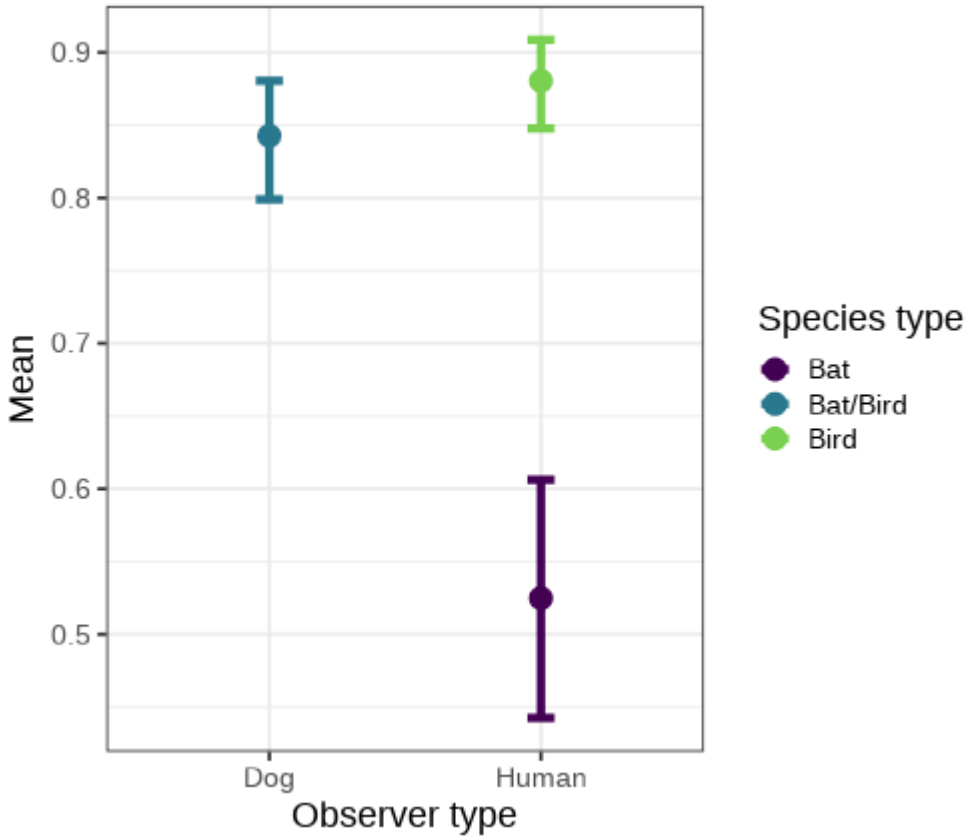
Scavenger profile

Archetype	n	Avg. days to loss	Lower bound	Upper bound
Bat	170	2.7	2.1	3.4
Bird - General	321	5.7	4.8	6.8
WTE	37	287.3	130.1	634.5





Searcher efficiency



Observer type	Species type	Mean	Lower	Upper
Human	Bird	0.88	0.85	0.91
Human	Bat	0.52	0.44	0.61
Dog	Bat/Bird	0.84	0.80	0.88

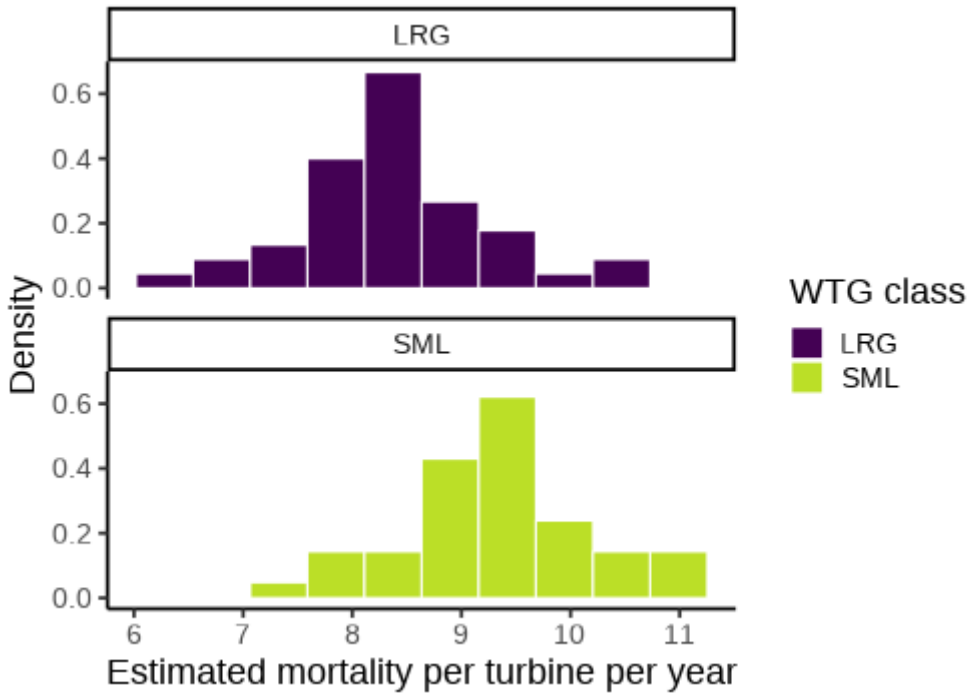
Key results

3. Total annual mortality by species group and turbine class

Annual mortalities per turbine - bats

WTG Class	No. found	Turbine years	Mean	CI lower	Median	CI upper
SML	334	151.30	9.27	7.97	9.25	10.78
LRG	94	49.57	8.36	7.03	8.39	10.12

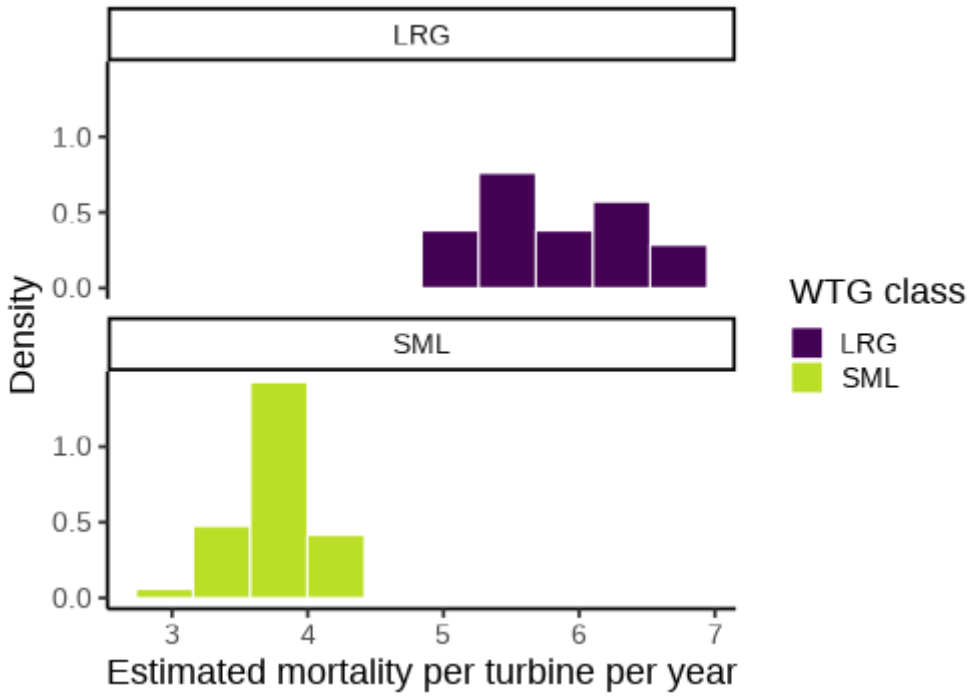
- Turbine size classes:
  - Small (SML) : Rotor swept height 35m - 132m (144ft - 433ft)
  - Large (LRG) : Rotor swept height 28m - 140m (91ft - 459ft)
- **Between 7 and 10.8 bat mortalities occur per turbine per year in Western Victoria**



Annual mortalities per turbine - birds

WTG Class	No. found	Turbine years	Mean	Std.Dev.	CI lower	Median	CI upper
SML	203	151.30	3.77	0.23	3.44	3.78	4.06
LRG	119	49.57	5.83	0.57	4.98	5.73	6.70

- No overlap - have not aggregated size classes.
- For small turbines, between 3.4 and 4.1 bird mortalities occur per turbine per year.
- For large turbines, the range varies between 5 and 6.7 per turbine per year.



Species mortality per turbine

Conclusions and implications

- First cumulative study of its kind in Australia
- 6 out of 7 turbines searches find no carcasses (but mortality can be estimated if good survey design is used)
- Turbine size influences the mortality estimate for birds
- Reference scavenger time and detection rate results
- For scavenge rate trials, mice are suitable bat proxies but chickens are too 'tasty'
- It takes a very long time to scavenge a Wedge-tailed Eagle to non-detectable (relevant for other large raptors?)
- Between 7 and 10.8 bat mortalities occur per turbine per year in Western Victoria
- About half of these are White-Striped Freetails
- Between 3 and 7 bird mortalities occur (more at larger turbines)

This is the first step towards a regional understanding of cumulative impact of turbine collisions on specific local species.

Acknowledgements

Symbolix would like to acknowledge and thank the following people for their valuable insights, contributions, and feedback:

- Belinda Cant, Chad Browning, Amanda Ashton (DELWP, Victoria)
- Emma Bennett (Elmoby Ecology)
- Rob Gration (EcoAerial)
- the multiple consultants and wind farm operators that submitted field data for analysis.

For more information or a copy of the full report and references please contact me via:
www.symbolix.com.au/wind-and-wildlife