Appendix 4: Guidance for post-construction mortality monitoring for birds and bats from onshore wind energy facilities

This Appendix provides guidance on DEECA's preferred methodology for the carrying out of post-construction mortality surveys.

Monitoring should commence immediately after the turbines are commissioned and start operating.

1. Intended outcomes from mortality monitoring

Post-construction mortality monitoring is used to understand the impacts of a wind energy facility on birds and bats once it becomes operational. Survey results can help to understand whether assessed risk levels were appropriate, whether mitigation measures are operating as expected or whether adaptive management measures are required. Post-construction monitoring can also inform understanding of cumulative impacts across multiple wind energy facilities and at a state-level.

To estimate mortality rates information collected should include:

- the number of mortalities
- location of mortalities
- search effort, including how many turbines are searched and how often
- searcher efficiency/ detection success
- carcass persistence or scavenger rates.

The Species of Concern should be the primary focus for post-construction mortality monitoring. However, monitoring should also record all bird and bat species found during searches to contribute to knowledge of the species being impacted and improve understanding of the drivers of mortalities.

2. Turbine selection

Wherever possible, all turbines in the wind energy facility should be included in mortality searches, noting this may not be practically feasible at large wind energy facilities. Where all turbines are searched, results will provide a high degree of confidence in the estimated level of ongoing impact.

Where more than 30 per cent of turbines are searched, results should estimate impact levels with a reasonable level of confidence if data collection is rigorous. However, specific characteristics of a site or unexpected results may trigger the need for increased monitoring to deal with remaining uncertainty, which should be prescribed in BAM Plans.

Where less than 30 per cent of turbines are proposed to be searched, a high degree of uncertainty will be associated with results and applicants should outline how they will address that uncertainty.

As there can be marked variation in annual mortality rates between turbines, if a proportion of turbines is to be searched, rather than all turbines, the following should be considered:

- The number selected should be rounded up to the nearest whole turbine.
- Any turbines pre-determined to present high mortality risk, for example based on pre-construction utilisation surveys or any post-construction monitoring already undertaken, should be included in the sample of turbines to be searched.
- The remaining sample should be stratified to ensure representation of factors such as habitat type, unlit versus lit turbines, and turbines located at the edge versus interior of the site, where relevant. Within these stratifications by factor, turbines should be chosen randomly without bias to ensure a representative sample.
- If stratification is not relevant to the site, then turbines should be randomly selected.
- Changing the selection of turbines each year will increase the likelihood that any mortality 'hotspots' are not missed. If this approach is applied, keeping a subset of turbines consistent between years will allow for comparisons of patterns between seasons and years.

3. Search area

The area to be searched under each turbine needs to be defined to ensure consistent search effort for each mortality survey. The search area should be defined in relation to the maximum fall zone for a carcass after collision, so that the proportion that are likely to fall outside the search area can be factored into the overall mortality estimates.

The fall zone of carcasses is broadly related to the turbine size. A search area linked to maximum blade tip height in the study design should therefore ensure the area is consistently scaled to different turbine sizes across different wind energy facilities. A search area based on modelled maximum fall distances should provide a consistent proportion of the mortalities to include in mortality estimate calculations.

Some uncertainty is inherent as modelling methods rely on, or are influenced by, a range of assumptions, for example, unknown aerodynamic drag parameters. Fall distance is also likely to be affected by factors such as prevailing wind direction, flight patterns and behaviour of species and the operating speed of the turbine, minimum ground clearance of the turbine blades, and the radial distribution of collisions across the turbine blades.

In all cases, clear documentation and justification for the design of the search area needs to be provided.

4. Search method and carcass detection protocol

Searches are conducted with either detection dogs or human searchers. Research, both in Australia and internationally, shows that detection dogs have a higher detection success and efficiency, especially for smaller birds and bats, and therefore is the preferred approach where feasible and practicable.

Human searchers have lower search efficiency and detection success. Any approaches proposing the use of human searchers should provide justification for the choice and report efficiency rates.

When using detection dogs to undertake searches, the following matters must be considered:

- Dogs used for searches must be trained in air scenting target odours (birds and bats).
- Handlers should have demonstrated experience in working with detection dogs, and a bond with the dog used, as well as experience in identifying local bats and birds to species level.
- Dog-handler teams should commence surveys downwind of the survey area and work perpendicular to the prevailing wind to maximise the probability of encountering scent cones produced by carcasses.
- Transects should be a maximum of 20m wide to avoid reduced efficiency, and the width should be reduced in unfavourable scent conditions such as high or still wind, tall vegetation, or when targeting small species.
- Collecting data on effort or time searching per area can help in comparisons between different dog-handler teams and provides important information for evaluating consistency and performance. In addition, information on start and finish times of each survey is important for evaluating fatigue, time of day and weather impacts when interpreting results. Dog tracks should be recorded with GPS collars, with the duration of search and the area searched recorded for each survey in minutes per hectare and submitted with survey data.
- Regular breaks, e.g. 5 min for every 20 min searching, and avoiding actively searching for more than 3–4 hours per day or searching during hot weather should maintain both animal welfare and optimal searcher efficiency. Panting decreases dogs' abilities to detect scent.
- Undertaking dog searches early in the morning reduces the chance that diurnal scavengers remove carcasses of nocturnal species before they are found and also avoids high temperatures.

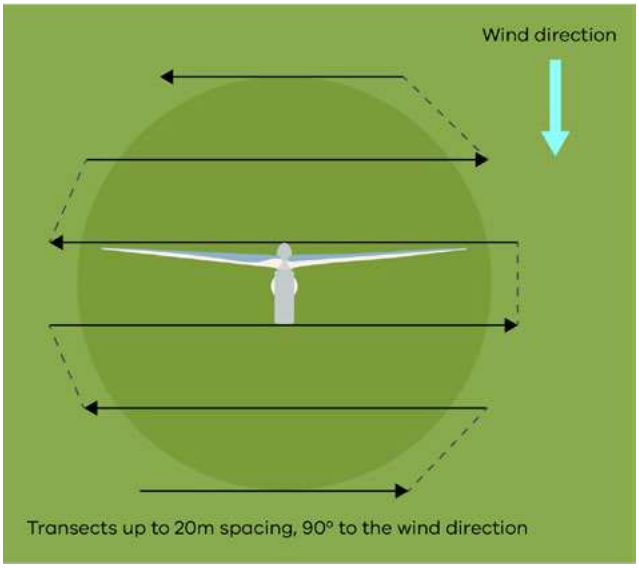

Figure 6: Searches by trained detection dogs are undertaken perpendicular to the wind direction, commencing downwind of the search area and using 20 m spacing or less, depending on the scent conditions.

5. Searcher efficiency trials

Searcher efficiency is the probability that carcasses are successfully detected by searchers when present in the search area. It is important to know the proportion of carcasses that are likely to have been missed to accurately estimate annual mortality rates. This proportion is estimated by conducting searcher efficiency trails.

Best results will be obtained from searcher efficiency trials when:

- Carcasses of each of the target groups of interest, i.e. small birds, medium birds, large birds, small bats, and flying-foxes, are used. Carcass proxies are not appropriate for searcher efficiency trials when using dogs, because they detect targets by scent.
- When humans are placing test carcasses, an easy scent trail is not left for dogs to follow directly to the target. Where possible, multiple people walking randomly throughout the survey area prior to the dog searching will help eliminate the dog tracking the person who placed the target to the carcass.
- Searcher efficiency trials are 'blind', i.e. dog handlers or human searchers should not be aware that the trial is being undertaken or of the number and type of carcasses placed. Observers aware of the target location should not be present during the survey.
- The number of carcasses used in each trial should vary, with some surveys containing zero carcasses.
- Searcher efficiency trials are integrated into normal searches (e.g. a couple carcasses per survey) for more realistically simulation of searcher efficiency.
- Testing of dog-handler teams occurs under the conditions that normal searches are undertaken so that factors such as fatigue and time of day are taken into consideration. For example, while morning searches are recommended, if searches will be undertaken at different times of day, then searcher efficiency should also be tested at different times of day to account for the effect of this variation.
- Separate searcher efficiency estimates are calculated for each dog-handler team due to differences in dog performance with different handlers.
- Search effort during the searcher efficiency trials is reported as the total search time per unit of area searched, e.g. minutes per hectare, to enable comparisons of consistency between searches and trials, between dog-handler teams, and under different conditions. This includes submitting GPS tracks from dogs alongside reporting data.
- The proportion of carcasses found is reported for each survey for each of the target groups (i.e. small birds, medium birds, large birds, small bats, flying-foxes).

Where appropriate searcher efficiency estimates based on an equivalent context are available, these may be an acceptable proxy for trial-derived estimates. Proponents should consult with DEECA before adopting this approach.

6. Carcass persistence trials

Carcass persistence trials or 'scavenger trials' determine how long carcasses remain in place before they are no longer detectable because they are removed by scavengers or degrade in the environment.

Considerations for carcass persistence trials:

- Because carcass persistence times vary with body size and between different taxa, trials should be undertaken for each target group, i.e. small birds, medium birds, large birds, small bats, and flying-foxes.
- Using like-for-like carcass types in trials will ensure accurate results for each carcass type or size class. Carcasses may be available from sources such as mortalities from turbine searches, heat stress events (flying-foxes), road collisions or animals that have died while in care, e.g. sourced from wildlife carers.
- Where proxies for carcass persistence trials are required, dark-coloured mice may be substituted for insectivorous bats. Scavenging times for mice have been shown to differ slightly to insectivorous bats in Victoria, though they follow a similar pattern and are therefore considered to be reasonable proxy if bat carcasses cannot be accessed.
- Accuracy of results generated where rabbits are substituted for flying-foxes in Victoria remains unclear, and confidence in results will be increased where this proxy has been calibrated with scavenger rates for flying-fox carcasses to determine its validity for providing accurate estimates.
- Carcass persistence trials undertaken every season over the monitoring program will account for seasonal variation.
- Trials undertaken over the full range of habitats present will account for spatial variation across the site, for example whether some areas are likely to have more scavengers than others based on the vegetation cover.

- Carcass persistence is influenced by factors such as rain and the types and numbers of scavengers present so results cannot be assumed valid if transferred from one site to another.
- Heat-and-motion cameras or regular site visits are typically used to determine the approximate time of removal or decomposition. Cameras provide advantages such as more precise times that carcasses are removed, determining the species that removed the carcass, and reducing the number of site visits required.

Practices that will improve accuracy of carcass persistence trial results:

- Carcasses are marked discreetly so that they can be discerned from actual mortalities.
- Carcasses are dropped from waist height rather than placing them directly on the ground.
- The location is recorded with a GPS.
- No more than two trial carcasses placed at any one turbine at a time to avoid altering typical scavenger activity at the site.
- If using the manual checking approach, site visits are undertaken on at least Day 1, 2, 3, 4, 7, 14, 21, and 30 (or longer for raptors). Fewer visits are needed when using camera traps, however cameras will still require checking to minimise data loss, e.g. checking for equipment failures or loss of cameras.
- The total number of carcasses of each type and size class to be used in the trials is guided by a statistician/biometrician.

Where appropriate carcass persistence estimates based on an equivalent context are available from other scientifically robust sources, these may be an acceptable proxy for trial-derived estimates. Proponents should consult with DEECA before adopting this approach.

7. Search intervals

Search intervals between mortality surveys effect the likelihood of detecting and correctly identifying carcasses, particularly for small-bodied species that are more likely to be scavenged quickly or decompose, which influences the accuracy of resulting mortality estimates.

Short search intervals of for example every 3–4 days are more likely to detect small-bodied species.

Intermediate intervals of for example 7 days may be appropriate where small-bodied species are not a focus of surveys.

Monthly surveys are likely to miss many mortalities due to carcass loss through scavenging. The addition of pulse surveys 2–3 days after standard monthly searches strikes a balance between short intervals suited to recovering small-bodied insectivorous bats and seasonal coverage across the year.

Higher sampling frequency over periods of higher collision risk for bats (late summer / autumn) will provide more robust data to assess bat mortality rates.

8. Identification, handling and management of carcasses or injured wildlife

Bat carcasses collected during mortality surveys and as incidental finds should be handled using gloves and by practitioners that are fully vaccinated for Australian Bat Lyssavirus and maintaining ongoing immunity through titre checks and obtaining boosters as required.

Any live, injured wildlife found should be transported to the nearest veterinary clinic. Victoria's Help for Injured Wildlife Tool[14] provides information on safety considerations and helpful contacts.

All carcasses collected during surveys or as incidental finds should be identified to species level, and where the condition of the carcass and presence of identifying features permits, identified by sex and life stage (adult, juvenile). Carcasses are to be kept frozen until they are no longer required, for example until any investigations and assessments have been undertaken. Carcasses may be able to be stored and used in future searcher efficiency and carcass persistence trials.

The handling, management and disposal of wildlife carcasses is a regulated by the *Wildlife Act 1975*. Proponents should consult with the Conservation Regulator to understand what authorisations may be required.

DEECA recommends that engagement with Traditional Owners or First Nations people is undertaken in the planning stages to understand any culturally sensitive management protocols for treatment of carcasses that may be requested, particularly for any culturally significant species.

14 https://www.wildlife.vic.gov.au/injured-native-wildlife/wildlife-tool

9. Minimum data requirements

The following data is required to estimate annual mortalities of birds and bats at wind energy facilities from post-construction mortality monitoring data.

Table 17: Minimum data requirements for post-construction mortality monitoring

Data category	Details required
Turbine details	For each turbine on each wind energy facility the following details are required: • Turbine identification number • GPS location • Description of location of turbine – such as raw if turbine is located on edge or in the centre of the array, availability of bird or bat habitat nearby, e.g. native vegetation or scattered paddock trees, wetlands. • Blade length • Minimum swept height (metres above ground) • Maximum swept height (metres above ground) • Hub height • Hardstand area (square metres) • Date the turbine commenced operations • Turbine lit – if the turbine has lights and if it was lit during the previous month
Searcher efficiency trials	For each time searcher efficiency trials were undertaken at a wind energy facility, the following information is required: • Date of trial • Weather conditions on day of trial • Blind trial – were searchers aware that a trial was being undertaken on that day, and if so, were they aware of the number of carcasses? • Name of the searcher • If a dog was used provide the name of the dog – Search transect details – include total area searched, distance walked and time spent searching, and the number of turbines searched. – Was it done as part of the normal mortality survey or specifically as a trial? – Were the carcasses randomly spread? – To what distance from the base were they spread? – For dog searches, the search effort (time per hectare searched) should be reported and the GPS-tracks from the GPS-logger carried by the dogs should be submitted. For each type of carcass – large bird, medium bird, small bird, small bat and flying-fox – provide the following: • Carcass – what species was used to simulate the carcass type? • Vegetation type (the density of the vegetation will influence detectability, so it would be useful to determine detectability for a range of vegetation types): – Bare ground – Short or sparse vegetation – e.g. short grass – Long or dense vegetation – e.g. long grass or heath • Number of carcasses deployed, and the number found in each vegetation type.

Data category	Details required
Carcass persistence trials	For each carcass used in a carcass persistence trial at a wind energy facility, provide the following information: • The category of carcass – i.e. large bird, medium bird, small bird, small bat, flying-fox • Carcass – the species of carcass • The date the carcass was put in place • The turbine it was closest to • Vegetation – virtually none, short or sparse vegetation, dense or long vegetation • Pest control etc. – date and details of any pest control that could impact carcass persistence rates, e.g. rabbit control, fox baiting, or other activities such as lambing under turbines, carrion removal • The number of days the carcass was checked and frequency of checks and/or the timing of camera trap deployment and checks after deployment. • For each check: – Date – Weather – general weather conditions since previous check – e.g. temperature and rainfall (as these will affect decomposition rates) – Condition of carcass – e.g. intact, partly scavenged, remnants only (e.g. feathers) or completely removed.
Mortality surveys	For each mortality survey undertaken at a wind energy facility, collect the following data – record information on all surveys irrespective of whether carcasses were located. • Date of survey • The number of turbines searched • Were turbines cleared of existing carcasses prior to commencement of scheduled searches? If so, how many days prior to the search? • Pest control, etc. – date and details of any pest control that could impact observation rates, e.g. rabbit control, fox baiting, or other activities such as lambing under turbines, carrion removal. • Weather conditions on the day of the survey • For each individual turbine searched: – Turbine number – Searcher's name – Dog's name if used – Search method – describe the search method, including duration of search, transect width, shape of search area, distance out from base, if GPS track was taken, etc. – Search area – estimated total area searched in square metres – Percentage of area searched that was bare ground – Percentage of area searched that was short or sparse vegetation – Percentage of area that was long or dense vegetation – Percentage of time the turbine was operational over the past 5 days – Percentage of time the turbine was operational over the past 30 days – Total number of carcasses detected in this search at this turbine. • For each carcass: – Species – Condition – injured, intact carcass, partial remains, scavenged, feathers only, etc. – GPS location – Distance to turbine base – Direction to turbine base (bearing) – Carcass identifier – who identified the species? – Vegetation within general vicinity of carcass – bare ground, short or sparse vegetation, dense or long vegetation

Data category	Details required
Incidental finds	For any incidental finds outside of the mortality surveys, collect a subset of the above data including: • Turbine number • Date • Searcher • Species • Condition – injured, intact carcass, partial remains, scavenged, feathers only, etc. • GPS location • Distance to turbine base • Direction to turbine base (bearing) • Carcass identifier – who identified the species? • Fate of carcass – was it removed or left in place to be included in mortality surveys? • Vegetation within general vicinity of carcass – bare ground, short or sparse vegetation, dense or long vegetation. Where carcasses are found incidentally outside the standardised mortality monitoring surveys, they should be recorded and reported, removed and stored in the same way as for carcasses found in normal surveys. Unless there is clear evidence that an incidental mortality find did not result from collision with a turbine, carcasses found within search plots but outside of a formal search should be included in mortality estimates under the assumption that the carcass would have been found in the next survey. Carcasses found outside of defined search areas around turbines should not be included in mortality estimates but do provide valuable information regarding the species being impacted.

10. Estimating annual mortality rates

The number of mortalities found during mortality surveys is only a proportion of the true number of mortalities occurring at a wind energy facility. By using additional information, including search effort and the results from searcher efficiency and carcass persistence trials, the annual mortality rates can be estimated for individual species. This information is critical for understanding the true number of individuals killed each year.

Mortality rate estimation should use statistically valid approaches (see below) for estimating mortality rates and provide estimates of variability/confidence/error associated with the estimates. The annual mortality rates should incorporate and be adjusted for:

- Search effort, including the number of turbines searched and the survey intervals
- Searcher efficiency rates
- Carcass persistence rates.

The number of mortalities likely to have been missed due to falling outside of the searched area (e.g. density weighted proportion of area searched).

Species-specific annual mortality rates should be estimated for each Species of Concern that have been detected as mortalities. Consideration should also be given to estimating rates for any other bird and bat species, such as highly-impacted or culturally significant species. It is recommended to report mortality estimates as a total across each wind energy facility per year, as well as on a per turbine and per MW basis.

A range of statistically valid approaches have been used for estimating annual mortality rates. Internationally, a standardised approach has been developed called GenEst – A Generalized Estimator of Mortality (https://connect.west-inc.com/GenEst/). This is a software platform into which numbers on mortalities, search effort, searcher efficiency and carcass persistence rates are entered, that then provides estimates of mortality with the associated uncertainty. This tool assumes regular survey intervals and cannot accommodate the pulse survey approach that is often undertaken in Victoria. More bespoke models are typically used in Victoria that can incorporate the pulse survey approach and also provide more interpretation on false negatives (i.e. where carcasses occur but have not been found).

11. Post-construction bat utilisation surveys

Post-construction utilisation surveys can provide further information and support comparison of the levels of bat activity before and after the construction of the turbines, to help interpret the mortality data and more fully understand the potential impacts of the wind energy facility.

Post-construction bat utilisation surveys can be undertaken in a similar way to pre-construction utilisation surveys. Benefits include:

- Post-construction bat activity at turbine nacelle can provide a good estimate of mortality risk to bats. This information can be valuable for supplementing data from post-construction mortality monitoring, especially for threatened species which can be difficult to detect in mortality surveys due to comparatively smaller numbers of mortalities (i.e. which are therefore more likely to be missed between survey periods) and because small bat species are scavenged very quickly.
- Acoustic monitoring of bat activity at nacelle, together with monitoring of weather and environmental variables such as temperature, windspeed and rainfall, can inform a site-specific 'smart' curtailment program which may be able to reduce energy loss through making curtailment as targeted as possible to identified risk factors for the species at risk.
- Information generated could inform investigations into indirect impacts such as habitat displacement or disturbance, or any attraction effects.

12. Data accessibility

External reporting and data disclosure/accessibility is important to enable meta-analyses to understand cumulative and population-level risks to species, informing strategic planning processes and future assessments, and to facilitate collaborative learning about the effectiveness of different mitigation measures.

Data collected based on minimum data requirements should be submitted to DEECA on an annual basis and made publicly available (subject to any necessary redactions for confidentiality or privacy reasons or related to ecologically sensitive information). All pre- and post-construction survey and monitoring data should also be entered into the Victorian Biodiversity Atlas.