MAXIMISING LEARNING OPPORTUNITIES WHILE REPLACING TREE-HOLLOWS FOR WILDLIFE

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Introduction

Nest boxes have been used in Australia since at least the mid-1970s (Menkhorst 1984), with an enormous number of studies documenting patterns of occupancy and rates of use by a range of different species. Despite occasional debate about the efficacy of nest boxes in the scientific literature in the intervening years (e.g. Harley 2006; Harley and Spring 2003; Lindenmayer et al. 2002; Mckenney and Lindenmayer 1994), there is only now a realisation that nest boxes are deficient in many respects when compared to other types of hollows, particularly natural hollows (e.g. Griffiths et al. 2018; Griffiths et al. 2017). As a result, there is a widespread and rapidly growing movement towards the use of carved hollows in standing trees rather than the installation of nest boxes.

A pertinent question as momentum for carved hollows grows is 'why has it taken at least 40 years to understand that nest boxes are not a panacea to the loss of hollows?' And an even more important question is 'what do we need to do over the next few years to ensure that we aren't still debating the merits of carved hollows in 40 years' time?'

Background

Habitat clearing, logging and selective removal of 'high risk' trees has caused a massive decline in the abundance of large and dead trees, reducing the abundance of tree hollows in urban, agricultural and timber production landscapes globally (Le Roux et al. 2014; Lindenmayer et al. 2014; Stagoll 2012). Trees in urban areas are typically managed to maximise health and amenity whilst reducing risk to the public and property and dead or decaying limbs and trees are typically promptly removed. These dead or decaying trees and limbs often contain valuable hollows, resulting in a net decline in the abundance of hollows. Determining the most effective method to increase the number of hollows is a critically important topic because over 300 species of native Australian birds, mammals, reptiles, and amphibians rely on tree hollows (Gibbons and Lindenmayer 2002; Goldingay 2009). Hollows form naturally when the heartwood of the tree is exposed due to fire or wind damage, which then allows natural decay processes to create the hollow. The outer sapwood of the tree is resistant to decay and forms the structural walls of the hollow (Gibbons and Lindenmayer 2002). In natural systems, eucalypt trees typically need to be at least 100 – 120 years old before usable-hollows develop.

Land managers have been using nest boxes for the past few decades as an alternative denning resource to natural hollows for a range of reasons, including:

- to offset hollows removed during a development;
- to increase or supplement hollows in an area for wildlife; and
- as targeted actions to recover declining or vulnerable hollow-dependent species.

Despite being used for the past few decades, nest boxes have repeatedly come under scrutiny and criticism because they:

- often have a relatively short lifespan, ranging from <5 to 10 years;
- some designs are prone to overheating in summer;
- can harbour invasive species, including European bees, noisy miners or support already abundant common species; and
- sometimes have low rates of uptake, particularly of the target species.

In response, there is a growing groundswell of movement and support for the use of hollows carved directly into standing trees with a chainsaw or other tool. There is a diversity of types of carved hollows, including the faceplate method, false door method, simple plunge cuts, coronet cuts etc, with very little strong or peer-reviewed evidence to support one method over another. Furthermore, other types of replacement hollows, such as salvaged log hollows and standard nest boxes are still being installed, leaving land managers with a bewildering array of options.

The way forward

Unless carved hollows are installed according to a scientifically robust experimental study design and carefully monitored and evaluated, it is highly likely that we will still be debating the relative merits of nest boxes, carved hollows, log hollows and natural hollows in 40 years time.

Hundreds or possibly even thousands of carved hollows are being installed around Australia each year and each project is an incredible opportunity to 'learn while doing'. However, the current typical approach to hollow replacement is to simply install the hollows that the land manager requests or arborist recommends, possibly record some details about the hollow or the host tree, maybe do some ad-hoc monitoring/inspections for a short period of time, and then as interest wanes or funding runs out, move onto the next project. With this approach, it will at best take a long time and much effort to generate sufficient reliable data to be able to evaluate the effectiveness of carved hollows because of the enormous variation in:

- the type, size and construction technique of hollows installed;
- the species, health and size of the host trees;
- the prevailing weather and other environmental conditions among sites;
- different management regimes (e.g. risk assessments, pruning techniques and intensity); and
- the type and quality of data being recorded.

The solution to this problem is for land managers to adopt the principle that every hollow being installed is an opportunity to 'learn about the use and effectiveness of carved hollows', as well as be an opportunity to replace hollows. In effect, every hollow installed should be considered part of an experiment, and by considering and adopting a few guiding principles, the maximum amount of reliable and robust information can be learnt in the shortest amount of time, leading to more rapid adoption of evidence-based best-practice techniques.

What features of an 'experiment' should I consider?

The first consideration is that land managers must recognise that they have a role to play in ensuring that they don't just install hollows, but that they actually commit to learning while installing hollows. Once a commitment to maximise learning opportunities has been made, the next step is to formulate the question to be answered or hypothesis to test.

For example:

- Does species X prefer a nest box, carved hollow, log hollow or natural hollow?
- Does species X prefer entrance sizes that are 50 mm, 60 mm or 100 mm diameter?
- How much longer will a nest box (of design X) last compared to a carved hollow?
- Which construction method for carved hollows is better?
- What are the impacts of carved hollows on tree health?
- Which species of trees are more- or less-suited to carved hollows?
- How does the wildlife population and/or community of species respond to the installation of carved hollows?
- What is the optimal density of carved hollows in different forest types and/or landscapes?
- What is the optimal aspect, wall thickness, color, material, etc of replacement hollows to support wildlife year-round?
- ____(fill in your questions here!)

It may be possible to begin to answer some of these questions now by compiling data and results from numerous installations and/or conducting inspections of hollows that have been installed. While it is often difficult to collate and use unpublished data sets because necessary information may not have been recorded; the monitoring may have stopped suddenly; data or metadata has been lost; or the study was biased in some way that prevents a sensible analysis, we should at least try.

Once the questions or hypotheses have been formulated, it is time to consider the design of the study. There are various experimental designs possible, and the most powerful design that maximises inferential strength (i.e. the ability to detect an effect, if one exists) should be selected. It is not possible to exactly specify which design should be adopted for your particular question(s) and situation, but in general terms, the most powerful designs include:

- Replicated Before-After, Control-Impact (BACI): where a variable of interest is measured at numerous experimental units (e.g. nest boxes, carved hollows, study sites) 'Before' and 'After' an intervention is made at the 'Impact' sites, as well as at sites which are not treated (i.e. 'Control' sites). If the question is 'Are the number of hollows limiting the population of an endangered mammal', a BACI approach might be to install 5 hollows per ha at three sites, 10 hollows per ha at another three sites, and 15 hollows per ha at another three sites, and leave another three sites with no additional hollows (i.e. the control) The density of the target species would be measured for an appropriate length of time at all sites before adding the hollows, and again after adding the hollows.
- Variations on the BACI design include reducing the amount of replication (e.g. fewer study sites or hollows), excluding the before and after comparison and/or excluding the control and impact comparison, however each downgrading of the design reduces the ability to detect a significant difference in the results.
- The effect of carved hollows on tree health would ideally be tested using a BACI approach, with variation in perhaps the size of the hollow, the species of tree, etc. In this example, say 40 trees of the same species, approximate size and similar health condition are selected within the study area, and half are randomly selected to receive hollows and half not. Then, the health and condition of both cohorts of trees are assessed annually over the next 5 – 10 years and compared.
- Confirming whether a species of wildlife prefers one type or size of hollow over another could be investigated by conducting a choice experiment, where a small number of different types or sizes of hollow are installed in close proximity to each other and the species chooses which it prefers. For example, identifying the preferred type of hollow for an endangered arboreal mammal could be achieved by installing a similarly-sized nest box, log hollow and carved hollow within 25 – 50 m of each other (i.e. installed as a triplicate) and subsequent monitoring evaluates rates of use by the target species.

The various options for analysis of the data are too many to list here, but data analysis is critical to ensure that the conclusions drawn are accurate and reliable, and expert advice should be sought.

Collaboration is critical to success

Most arborists and local land managers are neither trained nor experienced in the nuances of scientific study design and furthermore, conducting scientifically robust experiments is typically not part of core business for them. Therefore, a key component to undertaking high quality hollow installation programs as experiments is collaboration between arborists, land managers and researchers/scientists/consultants. The nature of the collaboration can range from the three groups working as equal partners to develop and undertake the project to one where the project manager consults or commissions an appropriately qualified ecologist for advice on study design and/or data collection and analysis. Collaboration among adjacent land managers to increase the number of hollows (i.e. replication) in the study is also beneficial because the cost per hollow may be reduced, sample size increased and more questions can be asked. Overall, greater collaboration on hollow installation projects is absolutely fundamental to:

- identifying the most important and relevant questions;
- developing the optimal study design, increasing sample sizes and asking more complicated questions;
- reducing costs and obtaining funding from alternative sources;
- identifying which data to collect and the most appropriate data collection methods;
- analysing the data and writing up the results, ideally in a peer-reviewed journal; and
- making the raw data publicly available for others to use and/or to combine with other data sets.

Case Study: Replacing hollows on a major development project

A hypothetical major development project through a high-quality patch of forest will result in the removal of 200 trees with hollows. The project proponent and regulator have read a recent critique of the use of nest boxes as an offset on a highway project (Lindenmayer et al. 2017) and have decided that nest boxes will not be used as a replacement strategy on this project. Instead, a combination of carved hollows and log hollows will be used to replace the hollows being removed, and the project will be set up as an experiment to test the relative effectiveness of each approach. In addition to replacing each of the 200 hollow-bearing trees with either a carved hollow or log hollow, nest boxes will still be used to provide a comparison to the 'standard' technique, as well as monitor a natural hollow. In effect, 100 groups of four hollows (one carved hollow, one log hollow, one nest box and one existing natural hollow, each within 50 m of each other) will be established in the vicinity of the project to provide replacement hollows for hollow-dependent species, as well as answer critical questions in a seriously powerful approach. The questions being asked include:

- What is the rate of use and preferences for different hollow types by different species?
- What are the impacts to the health and survival of the host tree and how does it differ among species, with three species of *Eucalyptus* being carved into?
- What is the longevity of the different types of hollows and how much maintenance is required?
- What are the thermal properties of the different types of hollows?
- Extensive opportunities exist to value-add to the project by supporting and facilitating university student research projects, including studying changes in animal abundance and community composition as a result of manipulating hollows.

The value of a project of this nature is that it achieves multiple objectives at very little extra cost, namely meeting the conditions of approval to replace one hollow for each hollow-bearing tree removed, as well as to undertake a scientifically robust experiment that maximises the information learnt to guide future hollow replacement programs. In addition, by offering opportunities for collaboration with researchers or university students, the project will achieve far more than simply meeting the basic conditions of approval.

Smaller-scale projects can offer similarly important opportunities for learning while doing by scaling back the questions and work and by collaborating with adjacent land managers.

Conclusions

The loss of large old trees and the loss of trees with hollows is a significant problem globally and particularly in Australia where hollows form slowly due to decay, rather than through active excavation by wildlife. Carved hollows in standing trees and the installation of salvaged log hollows are increasingly being adopted as alternatives to nest boxes, yet there is still much to learn. Every installation of a carved hollow is a potential data point in a larger dataset, provided a series of standardised measurements are taken of each hollow. Furthermore, numerous development projects that remove trees with hollows are being required to offset or replace these at scales that are perfectly suited to undertaking scientifically robust experiments with minimal additional investment. The approach briefly outlined in this paper will allow us to learn as much as possible and as quickly as possible, in order to develop the evidence-base for best-practice decision making and conserving wildlife that rely on tree hollows. Through collaboration and innovation we can all contribute to ensuring that we are not still debating whether carved hollows are an effective approach in 20 or 30 years' time.

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