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# Errors associated with two methods of assessing tree hollow occurrence and abundance in *Eucalyptus obliqua* forest, Tasmania

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**Abstract**

Tree hollows provide important habitat for fauna, but difficulties associated with detecting tree hollows can impede the formulation of appropriate management action. This paper examines the accuracy and errors associated with two methods commonly used to assess the presence/absence or abundance of tree hollows; 'ground-based' surveys and 'tree-felling' surveys. Three hundred and forty-six trees in Tasmania's State Forest were surveyed for hollows both before and after being felled. In order to assess the type and frequency of errors associated with each method, the fate of every potential hollow identified during the ground-based survey was determined after the tree had been felled. Three main types of error were identified: hollows misidentified during the ground-based survey; hollows not detected during ground-based surveys; and hollows not found during tree-felling surveys. Bayesian models were used to examine the association between site, tree and hollow variables and the occurrence of these errors. The likelihood that a tree would have a misidentified hollow increased with the number of potential hollows that were seen during the ground-based survey. Smaller hollows were more likely to be misidentified during ground-based surveys than larger hollows, particularly in trees that have little dead wood. For both of the survey methods the rate at which hollows were not detected was found to increase with tree size and hollow abundance. Hollows located in the branches were more likely to remain undetected during both survey methods, while small hollows, hollows high off the ground and those facing upwards were more likely to be missed during ground-based surveys. Although ground-based surveys provide inaccurate hollow counts, they are useful for assessing relative rather than true hollow abundance, which is valuable in the selection of habitat trees for retention in production forests. Tree-felling surveys provide a more accurate measure of actual hollow counts, particularly when a correction is made for the proportion of tree that cannot be surveyed. Tree-felling surveys are therefore useful for doing research such as developing models predicting hollow abundance.


*Keywords:* Tree hollows; Tree cavities; Survey error; Ground-based surveys; Tree-felling surveys; Bayesian regression; Forestry

## 1. Introduction

Cavities in trees, otherwise known as tree hollows, provide important habitat for a range of fauna throughout the world (Lindenmayer et al., 1996; Webb and Shine, 1997; Martin et al., 2004; Ruczynski and Bogdanowicz, 2005; Walker et al., 2005). Many hollow-using animals are considered threatened, which is often at least partially attributed to a lack of suitable nesting sites (Smith et al., 1985; Walker et al., 2005; Monterrubio-Rico and Escalante-Pliego, 2006). A decrease in the availability of hollow-bearing trees has been related to a range of factors including tree attrition, land clearance and silvicultural treatments (Gibbons and Lindenmayer, 2002).

In managed production forests, hollow-bearing trees are often retained to provide habitat for hollow-using fauna (Healy et al., 1989; Wayne et al., 2006). In order to ensure the tree retention guidelines provided are appropriate, information is required on the availability of hollows in different forest types, the proportion required to maintain populations of hollow-using fauna and the types of trees likely to provide habitat. However, hollow formation results from a number of deterministic and stochastic processes in hardwood forests, and identification and measurement of tree hollows can be difficult. The difficulties associated with identifying tree hollows can impede the formulation of appropriate management guidelines (Healy et al., 1989).

There are three methods that are commonly used to assess the availability of hollows: searching trees from the ground with the use of binoculars (ground-based or pre-fall surveys);

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Table 1
A summary of the advantages and disadvantages of three methods for assessing the hollow resource

| Survey method | Advantages | Disadvantages | Example references |
|---|---|---|---|
| Ground-based survey | • Quick<br>• Cheap<br>• Useful for determining hollow presence<br>• Potentially useful for determining hollow density<br>• Usable for all land tenures | • Inaccurate<br>• Difficult in dense forest<br>• Provides limited data on hollow attributes and use | • Lindenmayer et al. (2000)<br>• Munks et al. (in press)<br>• Walter and Maguire (2005)<br>• Chambers and Mast (2005) |
| Tree-climbing survey | • Provides accurate hollow counts<br>• Potentially provides information on hollow use<br>• Usable for most trees and forest types | • Time consuming<br>• Expensive<br>• Requires specialist skills<br>• Produces smaller sample sizes for the same effort | • Harper et al. (2004)<br>• Haseler and Taylor (1993)<br>• Ruczynski and Bogdanowicz (2005) |
| Tree-felling survey | • Provides hollow count data useful for research<br>• Provides an assessment of hollow use | • Study areas limited because trees need to be felled<br>• Useful for research only and not habitat tree selection | • Gibbons et al. (2000)<br>• Whitford (2002) |
| | • Relatively quick and cheap so provides large sample sizes | • Provides limited accuracy due to trees smashing or hollows being obscured | • Mackowski (1987) |

climbing trees; and searching trees felled during a logging operation (tree-felling or post-fall surveys) (Table 1).

Ground-based surveys are quick and cheap, making them a useful and practical way to assess the presence of hollows in a tree (Table 1). However, this method does not provide accurate counts of hollow abundance (Healy et al., 1989; Harper et al., 2004). Viewing hollows from a distance can be difficult, especially under low light conditions, or when obscured by foliage. Fire damage to the bark, sap stains or other marks can be mistakenly identified as being a hollow. In addition, most definitions of a hollow include a minimum depth (Whitford, 2002; Harper et al., 2004), which cannot be accurately determined from the ground. This means that not all cavities identified during ground-based surveys will meet the definition of being a true hollow. As well as providing inaccurate counts of hollow abundance, ground-based surveys provide incomplete or inaccurate information on hollow dimensions and use of hollows by fauna (Gibbons and Lindenmayer, 2002).

Climbing trees to search for hollows, either with ropes or ladders, results in a large improvement in data quality, potentially providing accurate information on the occurrence and characteristics of hollows in a tree and the use of the tree by fauna (Haseler and Taylor, 1993; Harper et al., 2004; Martin et al., 2004). However, when using ladders only small trees or hollows lower down the tree can be examined (Martin et al., 2004). The use of ropes requires specialised skills and is extremely time-consuming, thereby limiting the number of replicates that can be obtained within a particular budget (Table 1).

Tree-felling surveys can be done relatively quickly, thereby allowing larger sample sizes than tree-climbing surveys. They also allow collection of detailed information on the presence/absence, abundance and characteristics of hollows and their use by fauna. The largest samples of the internal dimensions of hollows, which are related to their use by fauna, have been obtained from tree-felling surveys (Gibbons and Lindenmayer, 2002). The disadvantages of this method include the fact that sampling is biased towards areas that have been approved for logging (Gibbons and Lindenmayer, 2002), that the technique cannot be used to identify habitat trees for retention in production landscapes due to the destructive nature of the sampling and that sections of some trees smash on felling or are obscured by the ground or logging debris (Table 1). The degree to which trees smash on felling depends on a variety of factors, including the amount of rot or dead wood they contain, the steepness of the slope on which they are felled and their height.

Of these three survey techniques, the one most often used by forest managers to assess the hollow resource is ground-based surveys. Such surveys are a good way to rapidly identify hollow-bearing trees for retention in production forests. Yet because hollows may be falsely identified or missed completely during a ground-based survey (Healy et al., 1989), it is important to understand the accuracy of this technique. High error rates may mean the availability of hollows is overestimated or underestimated. Unsuitable trees may be retained for animal habitat in production forests if hollow presence is overestimated. There have been some attempts to assess the accuracy of ground-based surveys (Healy et al., 1989; Whitford, 2002; Harper et al., 2004). This has been done by comparing the number of hollows seen during a ground-based survey and those recorded using an alternative method, such as tree-climbing. These studies have generally acknowledged that ground-based surveys provide inaccurate estimates of hollow abundance, but they varied in how useful they perceived this survey method as being (Whitford, 2002; Harper et al., 2004).

Correlating the results of two different methods is a sensible strategy when the alternative survey method provides accurate counts, as occurs with tree-climbing. However, when the alternative method is also inaccurate, as results from tree-felling surveys will be, it may be difficult to draw reasonable conclusions. To avoid the issue of inaccuracy in tree-felling surveys, some authors assume that error rates (the degree to which trees are smashed or obscured) are constant for all trees (Gibbons, 1999). Assuming a constant rate of error allows the