Preliminary assessment of reliability indicators for predicting mature eucalypt habitat in Tasmania

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1. Introduction

This report provides an assessment of the reliability of predictive mapping of mature eucalypt habitat availability as part of the assessment of High Conservation Value (HCV) forests by the Independent Verification Group (IVG) established under the Tasmanian Forest Inter-Governmental Agreement between the Australian and Tasmanian Governments. Under the IGA, areas proposed by Environmental Non-Government Organisations (ENGOs) as conservation reserves ("ENGO forest polygons") that are outside existing dedicated formal reserves have been referred to the IVG for assessment of forest conservation values..

The availability of mature eucalypt habitat is important for a range of hollow-dwelling and hollow-dependent vertebrate species that rely on these features for facets of their life cycle. Older forests in which hollows are present may also host a range of other biota (e.g. invertebrates and lower plants) whose occurrence is tied to the habitat features present in older forests.

Loss of hollow bearing trees is widely recognised as a threat to the survival of a wide range of Australian vertebrate fauna, and has statutory recognition as a threatening process in New South Wales and Victoria. However, information on the specific habitat requirements for a large proportion of hollow dwelling species is lacking. Goldingay (2009[1]) has reported that the hollow requirements of only 35 of Australia's 114 hollow-using bird species and 15 of 42 hollow-using microbat species have been documented in some detail.

In response to the lack of knowledge, generic approaches to the management of hollow bearing habitat have been developed. In Tasmania, tree hollows have been identified as used by 5 species of arboreal marsupials, 8 species of bats and 29 species of birds, with the highest diversity of hollow-using species associated with dry forest areas (Koch et al. 2009[2]). Hollow dwelling species are identified as a collective group under the Tasmanian Regional Forest agreement to be managed through a range of mechanisms, including the Forest Practices System and reservation.

To assist in the assessment and management of hollow dwelling species habitat, the Forest Practices Authority has developed predictive mapping of mature eucalypt habitat availability for the Tasmanian forest estate (Koch, 2011[3]). The map has been developed through application of formulae to GIS data of air photo-interpreted forest mapping of PI-described mature forests, based on previous field testing in wet and dry forests (Koch and Baker, 2011[4]). It presents predicted mature eucalypt availability as four classes - negligible, low, medium and high.

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[1] Goldingay, R.L. (2009). Characteristics of tree hollows used by Australian birds & bats. Wildlife Research, 36(5):394-409.
[2] Koch, A.J., Munks, S.A. & Woehler, E.J. (2009). Hollow-using vertebrate fauna of Tasmania: distribution, hollow requirements & conservation status. Australian Journal of Zoology, 56(5):323-349.
[3] Koch, A. (2011). Explanatory notes on the mapping of areas that potentially contain mature forest characteristics (the 'mature habitat availability map'). Fauna Technical Note 2, Forest Practices Authority, Hobart.
[4] Koch, A.J. & Baker, S.C. (2011). Using aerial photographs to remotely assess tree hollow availability. Biodiversity & Conservation, 20(5):1089-1101.

The mature habitat availability map carries a number of provisos around the need for updating to reflect improved data, as well as limitations in relation to use of remotely-sensed data, currency of data, and inherent variability in the abundance of tree hollows across the landscape and within the same PI-type codes.

This report provides a preliminary assessment of reliability aspects of the mature habitat availability map against quantitative data on tree hollow abundance collected through a rapid field survey method.

The purpose of the report is to assist the IVG in interpreting the significance of ENGO reservation proposals for the protection of hollow dwelling species, and to provide useful perspectives for the future development and refinement of the mature habitat availability map and management provisions for hollow dwelling species.

Section 2 provides a summary of the methods used to conduct the field survey. It identifies the data that were collected during the field survey and describes the cross-tabulation with data from the mature habitat availability map.

Section 3 provides analysis of the data assembled for the project. A range of statistical tests are applied to the data to help identify key aspects of the reliability of the predictive mapping of mature habitat.

Section 4 provides a brief discussion of the results and a summary of conclusions drawn from the analysis.

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2. Methods

2.1 Field survey method

The field survey method adopted for the project was designed to facilitate rapid collection of data over relatively extensive geographic areas. It employed data collection using the point-centred quarter method (Mueller-Dombrois and Ellenberg, 1974[5]) from survey points located predominantly on roads and vehicular tracks (see Section 2.2 for site selection information).

The following data that were collected at each survey point.

Distance to nearest hollow bearing tree
The estimated distance to the nearest hollow bearing tree in each of the quadrats around the survey point was recorded. Hollow identification followed size characteristics used by Koch and Baker (2011[6]). Distances were estimated to within five metres, up to a maximum of 50 metres. Estimated distances were periodically measured to ensure consistency in data recording. Where no hollow bearing tree was observed within 50 metres a default of 100 metres was used in the data analysis to reduce the skew from null values. All quadrats were recorded clockwise around the point, relative to the direction of vehicle travel.

Left and right side vegetation characteristics
Other data related to the vegetation at each survey site were recorded for both the left and right hand side of the road, relative to the direction of travel, due to the frequency of changes in vegetation characteristics across roads (e.g. arising from forest harvesting history). Data recorded for each side of the road were:

- Tasveg vegetation community;
- Forest age structure based on relative crown cover (mature, predominantly mature, predominantly regrowth, regrowth and regeneration from clearfelling);
- Whether the forest would classify as old growth forest, using the field methodology of the Forest Conservation Fund (AMAP, 2007[7]); and
- An estimate of the Biophysical Naturalness class of the forest, based on application of the decision rules developed for mapping during the RFA (TPLUC, 1996[8]).

Creekline vegetation
Survey sites occurring on creeklines were recorded in the data.

Survey site identifiers
Each survey site was given a unique identifier for reference. Each survey point was recorded in terms of:

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[5] Mueller-Dombois, D. & Ellenberg, H. (1974). Aims & methods of vegetation ecology. John Wiley & Sons, New York.
[6] Koch, A.J. & Baker, S.C. (2011). Using aerial photographs to remotely assess tree hollow availability. Biodiversity & Conservation, 20(5):1089-1101.
[7] Assessment Method Advisory Panel (2007). Forest Conservation Fund field assessment manual. Department of Environment, Water, Heritage & the Arts, Canberra.
[8] Tasmanian Public Land Use Commission (1996). Tasmanian-Commonwealth Regional Forest Agreement background report part C: Environment & Heritage report volume II. November 1996. Tasmanian Public Land Use Commission, Hobart.

- The data the site was surveyed;
- Initials of the recorder; and
- GPS waypoint number for the site.

Not all data recorded during the survey has been analysed for this report.

2.2 Field site selection

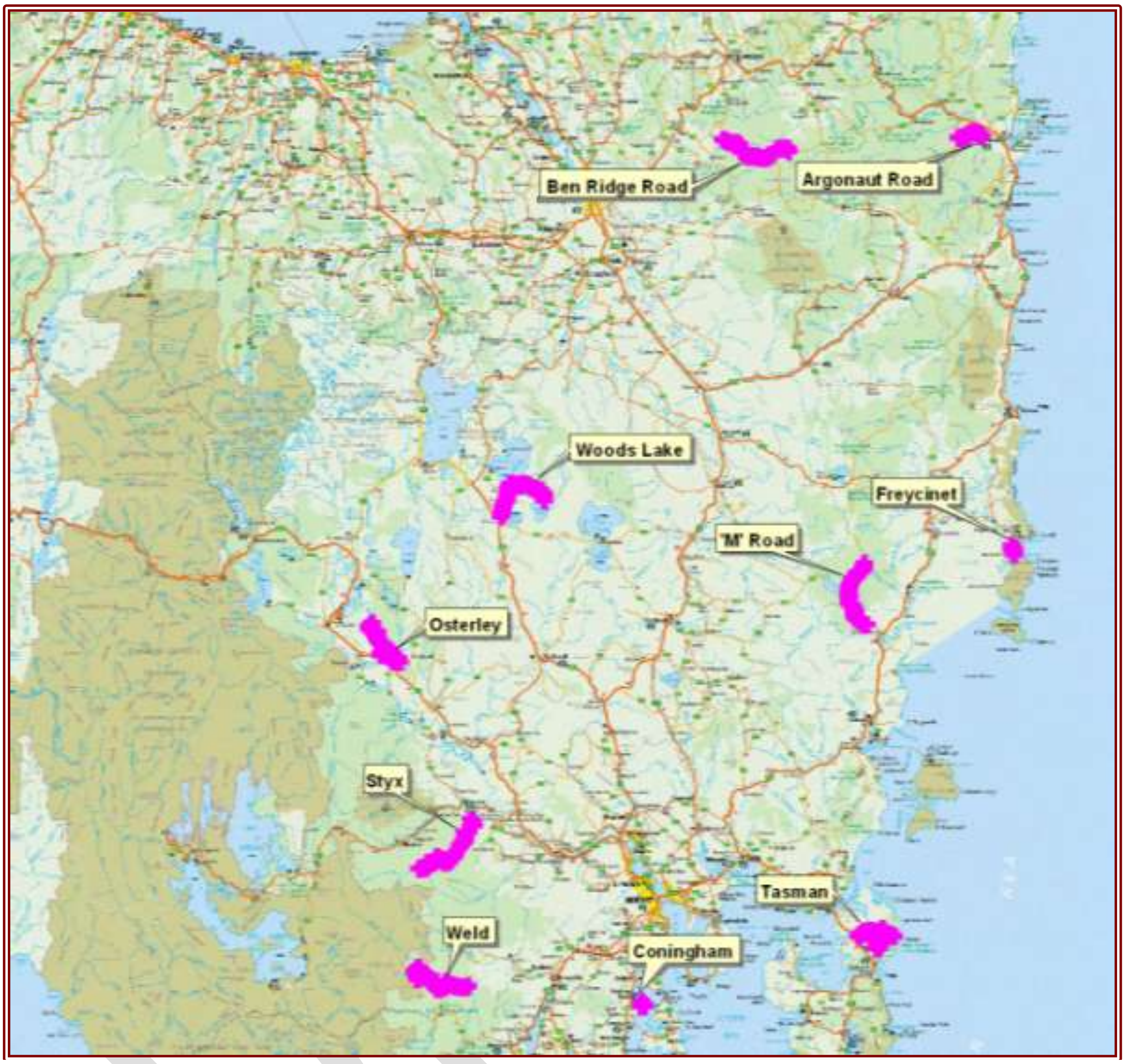
Field site selection was stratified to include forests within different parts of the State (and hence different forest types), subject to limitations arising from the short period during which the survey was undertaken. Eight areas in the south, east and north-east were targeted for vehicle based surveys. Smaller sets of data were also obtained from a further two areas that were traversed on foot. Figure 1 shows the location of the survey sites.

Site selection for vehicle-based survey
Site selection was designed to generate small clusters of survey points located separated by a near-regular distance to ensure randomisation in site selection. The following described the site selection process:

- A random site was selected as soon as possible on entering the forest in an area to be assessed;
- The initial site was surveyed along with others a further 100m and 200m along the road in the direction of travel;
- A further 300m was then travelled before again surveying three sites as described above;
- Site selection was varied where vegetation was unsuitable for hollow bearing trees (e.g. plantations) or where there were differences in vegetation characteristics between the roadside forest and that further away, or transverse to the survey point; and
- All crossings of streams were surveyed as a single point, where not part of a three site cluster.

Site selection for foot surveys
Site selection for foot surveys was estimated at distances approximately every 200 metres along the survey route, and also included all crossings of streams.

Figure 1. Location of field survey sites



2.3 Attribution of mature habitat availability data

Following completion of field surveys, all sites were plotted in a GIS and compared with the mature habitat availability mapping.

Map classes were added to the field data separately for both the left and right side of the direction of travel. Some interpretation of the mature habitat class to be assigned at particular sites was required where mapped class boundaries coincided with survey points, including rejection of sites where a clear habitat class could not be determined.

The existence of survey sites where the mapped mature habitat class was not identical on sides of the road precludes their use in analysis based on the point-centred quarter method. Each survey point was therefore attributed according to its suitability for different types of analysis:

- Survey points occurring where the mapped mature habitat was identical on both sides of the road/track were tagged for inclusion in analysis of density measures derived from the point-centred quarter method using data from all four quadrats; and
- Survey points where the mapped mature habitat was different across the road were tagged for inclusion in analysis of the individual measures of distance to the nearest tree hollow, using each of the 11 distance measures (every 5 metres to 50 metres, plus >50 metres) as a categories.

3. Summary of results

3.1 Survey sites

The field survey generated data for 606 survey points in native eucalypt forest suitable for analysis using the measures of distance to the nearest hollow bearing tree. Of these survey points, 408 had no variation in mapped habitat availability across the survey path and were suitable for analysis of hollows density using each of the four quadrats at the point.

Table 1 shows the breakdown of survey sites by area and suitability for analysis.

Table 1. Number of survey points by survey area and analysis suitability

Survey area	Total survey sites (suitable for distance analysis)	Survey sites suitable for density analysis
Agronaut Road	37	31
Ben Ridge Road	46	32
Coningham	8	8
Freycinet	18	18
'M' Road	79	59
Osterley	87	46
Styx	84	56
Tasman	83	44
Weld	84	65
Woods Lake	80	49
Totals	***606***	***408***

3.2 χ2 test

A χ2 test was used to provide a basic analysis of significance across the whole data set using the data on distance to the nearest hollow bearing tree. Although not the most suitable method for statistical analysis of the data, it is included as a means of comparing the results that arise from application of different analytical methods. It also provides a basis for viewing the distribution of the survey data.

A χ2 table was generated by tabulating the number of data points in each of the 11 recorded distance classes against the corresponding mapped mature habitat classes. Table 2 shows the tabulation of the survey results.

Table 2. Distribution of distance to hollow bearing tree classes

Mapped class	Distance to hollow bearing tree (m)											
	5	10	15	20	25	30	35	40	45	50	>50	*Totals*
High	18	26	44	46	62	56	64	34	22	44	49	***465***
Medium	7	13	11	11	24	17	15	10	3	8	45	***164***
Low	24	28	43	46	55	82	63	50	25	91	227	***734***
Negligible	8	17	24	40	36	47	37	34	19	77	665	***1004***
Totals	***62***	***94***	***137***	***163***	***202***	***232***	***214***	***168***	***114***	***270***	***986***	***2367***

The data indicate that the results are highly significant. The $\chi 2$ value of 699 is well in excess of the threshold for 20 degrees of freedom of 45 to be significant at 0.001% probability.

The results also indicate that the distribution of the data does not have a normal distribution. The data is skewed by the large number of survey sites in the negligible mapped habitat class, and by the (not unexpected) dominance of this class by sites where the distance to the nearest hollow bearing tree is >50m. When the negligible class is removed from the analysis, the result remains highly significant, with a $\chi 2$ value of 238.

3.3 Mean and standard error analysis

Calculation of the mean and standard error was used to assess the differences between the mapped habitat classes relative to the values recorded from field survey. The analysis has been performed on both the full data set using the distance measure, and also on the subset of the data where a density measure could be calculated. Table 3 shows the results of the analysis, which are also shown in Figure 2.

Table 3. Mean and standard error for field survey data

Mapped habitat class	Field survey results			
	Mean density (trees / ha)	**Standard error**	**Mean distance (m to hollow)**	**Standard error**
High	12.09	0.98	36.16	1.15
Medium	7.53	1.44	46.46	2.70
Low	7.65	0.84	52.29	1.25
Negligible	2.94	0.34	77.23	1.04

The results of the distance analysis indicate that each of mapped habitat classes are unique and non-overlapping. However, these data are influenced by these of a default value of 100 metres distance where no hollow bearing tree was observed within 50 metres. Hence they should be interpreted as indicative of a trend rather than actual values.

The results of the more reliable density analysis indicate that the Negligible and High mapped classes are unique and non-overlapping. However, there is no significant difference between the Medium and Low classes. This may arise from the lower number of Medium mapped sites (see Table 2) or from issues in the predictive mapping methodology and input data. If the Medium class is considered as part of the Low class, then a set of three significantly different density classes emerges from the data.

3.4 Regression analysis

Regression analysis was used as a higher level statistical test for significant relationships between the mapped habitat classes and the field survey data. It was also used to investigate differences in characteristics between different areas in the survey and to compare the two analysis methods. Table 4 shows the regression and R^2 values for the data as a whole and for each of the different survey areas. Data from the Coningham survey were excluded due to the low number of survey sites (n=8).

Table 4. Results of regression analysis

	Field survey results			
Survey area	**Density R**	**Density R^2**	**Distance R**	**Distance R^2**
All survey sites	0.404	0.163	0.299	0.089
Argonaut Road	0.096	0.009	0.077	0.006
Ben Ridge Road	0.589	0.347	0.330	0.109
Freycinet	0.174	0.030	0.105	0.011
'M' Road	0.626	0.392	0.527	0.278
Osterley	0.653	0.426	0.402	0.162
Styx	0.254	0.064	0.239	0.057
Tasman	0.623	0.389	0.212	0.045
Weld	0.533	0.306	0.243	0.059
Woods Lake	0.311	0.097	0.332	0.110

The regression analysis indicates relatively low statistical significance for the data as a whole. It also indicates that there is variation in reliability of the mapping between different geographic areas. Higher R^2 values for density in some areas (Ben Ridge, 'M' Road, Osterley, Weld and Tasman) than for the data as a whole occur in a variety of forest types. This suggests that in those areas the predictive mapping methodology is accounting for some of the inherent variability.

Lower R^2 for density in other areas may arise due to a number of factors. Two areas (Freycinet and Woods Lake) are of lower commercial interest for forestry and may have older or coarser PI-type mapping in the input data. One area (Argonaut Road) contained a high number of sites dominated by *Eucalyptus sieberi* forests. This species produces extremely durable timber and casual observation indicated few hollows in the species, with the majority of hollows in this forest community in minor species within the forest (*E. amgydalina* and *E. viminalis*).

The results also show a lower level of statistical significance when using density measures, based on data from all four quadrats at sites with no variation in mapped habitat class, and those where the distance measures alone were used. Approximately on third of all sites could not be analysed using the density measure but were included in the distance assessment.

4. Conclusions

The data collected from the survey was highly stratified and large in volume, and has not been analysed thoroughly due to time constraints on the project. Hence any conclusions should be regarded as preliminary and be used as an input to ongoing development and refinement of the mature habitat availability mapping.

Survey method
The analysis identified higher levels of statistical significance for data collected using the full point-centred quarter method at sites with no side to side variation in mapped habitat class than at sites where distance-based analysis was used, which included sites with side to side variation in mapping.

This has implications for field-based surveys as the efficiency of data collection is reduced due to the frequency of forestry roads forming boundaries between areas with different management history. It is nonetheless considered that the survey did demonstrate efficiency in the application of a rapid survey method to cover larger geographic areas.

Overall trends
The results indicate that the predicted mature habitat availability map provides a valid representation of variation in the density of hollow bearing trees, with limitations that have been previously acknowledge by the Forest Practices Authority and confirmed here. The $\chi 2$ and mean and standard error analysis both point to clear differences between the mapped Negligible, Low and High habitat availability classes that form a trend towards increasing numbers of hollow bearing trees. The Medium habitat availability class appears to be more similar to the Low class and may need to be modified or merged to increase reliability.

The variation in statistical significance between the first two analyses and the regression analysis indicates that reliability of the mapping needs further assessment. This is consistent with the FPA notes on limitations and use of the map, which are endorsed.

Geographic variation
The analysis showed considerable variation in the density of hollow bearing trees between geographic areas in the survey. The higher statistical significance of the density analysis for some areas, when compared to the overall regression analysis, indicates that the mapping methodology is accounting for variation in some areas. However, the extent to which this is an artefact of the methodology or the input data has not been determined and requires further examination.

Ongoing development
There are a number of areas of ongoing development of the mature habitat map that would enhance its effectiveness in assisting the management of hollow dwelling species. These include:

- The addition of a reliability code for the input data from the PI-type mapping, for example based on they year of the most recent update or the date and scale of the aerial photography used. This could help guide the implementation of management actions for mature eucalypt habitat and also assist the identification of priority areas for refinement.

- Further analysis of the field survey data, and data from other sources, should be undertaken as part of the ongoing development of the map. Analysis of geographic variation in tree hollow characteristics (e.g. decay rates in response to climate) and of variation between different forest types (e.g. between species more/less likely to form hollows) would also enhance the utility of the mapping.
- It was not possible in the time available for the survey to include recording data relating to hollow size or the numbers of hollows in individual trees, i.e. size and density data are currently lacking. Opportunities to enhance data on these aspects of mature habitat should be pursued.
- The survey was undertaken primarily on public land. The explanatory notes for the mature habitat map identify issues with the currency of PI-type data for private land. This introduces an unknown degree of uncertainty about the reliability of the mapping in these areas, which should be rectified where possible due to the reliance of some hollow dwelling species on forests that mainly occur on private land (e.g. the Masked Owl).

Implications for IVG forest assessment

This project was undertaken with a view to supporting the assessment of ENGO reserve proposals being undertaken by the IVG. The survey effort was limited to areas that were accessible by road, whereas some of the ENGO proposals are in predominantly unroaded areas. It is considered that, for the parts of the State that could be surveyed in the available time, forest types similar to many of those in the ENGO proposals were assessed.

The analysis supports the use of the mature habitat availability map as one method for assessing the habitat value within the ENGO proposed reserves, subject to the acknowledged limitations of the mapping. The statistical distinctiveness of the High predicted class on one of the analysis methods supports this view. However, it is also noted that the data is characterised by significant variation in hollow density within the classes, and areas of higher hollow abundance also occur in forests mapped as of Negligible, Low and Medium habitat availability also occur.

The extent to which the ENGO reserve proposals are representative of the range of hollow dwelling fauna has not been assessed as part of this project. Some hollow dwelling species are known to occur predominantly in forests outside the ENGO proposals, on public land and particularly on private land. This remains a significant data gap that will need to be addressed irrespective of the outcomes of the IGA negotiations, as securing the conservation status of the State's hollow dwelling species will most likely require a whole of landscape approach, which is consistent with the requirements of the RFA and the direction being pursued by the Forest Practices Authority.