8. General conclusions and recommendations

8.1 General conclusions

1. The surrogate evaluation techniques developed in this consultancy provide an objective basis for assessing the performance of a wide range of environmental surrogates. The techniques are sufficiently generic to be applied to data from any geographical region. The only requirement is a dataset containing both surrogate data and real biological data recorded at the same set of survey sites. Of the two techniques developed, species accumulation analysis provides a better measure of the performance of surrogates as a basis for reserve planning than matrix correlation analysis. While the developed techniques offer a good interim basis for evaluating surrogate performance there is considerable scope for refining the existing procedures and for investigating alternative approaches to the problem of surrogate evaluation.

2. Application of the surrogate evaluation techniques to environmental and biological data from forested north east NSW has revealed clear differences in surrogate performance, both between different types of surrogates and between different biological groups. All surrogates perform poorly for ground dwelling invertebrates. Reasonably consistent differences in performance between broad types of surrogates are apparent for all vertebrate and vascular plant groups. The poorest performing surrogates are those derived purely from abiotic environmental data, i.e. environmental domain classifications and environmental ordinations. Canonical ordination (CCA) performs marginally better than purely abiotic classification and ordination for flora, but provides little improvement for vertebrate fauna. Forest type mapping generally outperforms all types of environmental classification and ordination for both vertebrate fauna and vascular plants. The best overall performance of any surrogate is achieved by modelling of species distributions, especially when modelling is applied to species within the biological group under evaluation. The use of models for one biological group as a surrogate for other biological groups also appears to have potential. In particular, modelled canopy trees perform better than forest type mapping as a surrogate for both canopy and understorey flora, and for vertebrates. Caution should be exercised in generalising these results from north east NSW to other regions, due to the potential effect of environmental variation and differences in data quality and availability.

3. A further trial application of the surrogate evaluation techniques to data from arid north west NSW has demonstrated the applicability of these techniques to different environments and different types of surrogates. All mapped descriptors for this region (geology, landform, land systems, land units) perform very poorly as surrogates for vascular plants. This result highlights the importance of considering regional differences when evaluating the performance of surrogates.

4. The techniques for evaluating accuracy of predictive species models developed in this consultancy provide an objective basis for assessing the performance of a wide range of modelling approaches. The techniques can be used to assess the overall accuracy of presence/absence models and the discriminatory ability of either presence/absence or presence-only models.

5. Application of the model evaluation techniques to biological and environmental data from forested north east NSW has revealed clear differences in performance between different modelling approaches. Models derived from presence/absence data perform better than models derived from presence-only data. Generalised additive modelling provides better performance than generalised linear modelling, which in turn performs

better than decision tree modelling and BIOCLIM. Models perform better when derived using finer scale environmental data, especially in conjunction with accurately georeferenced presence/absence data. Modelling of species with strong environmental relationships performs better than modelling of species with weak environmental relationships.

8.2 Recommendations

1. The evaluation techniques developed in this consultancy should be employed as an interim standard for evaluating the performance of environmental surrogates and predictive modelling techniques.

2. Further investigation of alternative approaches to the evaluation of environmental surrogates and predictive modelling techniques should be encouraged. Refinement and extension of the techniques developed in this consultancy should also be facilitated, particularly the enhancements to species accumulation analysis proposed in Section 3.6.

3. Results from the evaluation of surrogates and modelling techniques in forested north east NSW (Conclusions 2 and 5 in Section 8.1) should be used as an interim guide to the relative performance of surrogates in similar forest environments elsewhere in Australia. Caution should, however, be exercised in extrapolating these results to other regions, due to the potential effect of environmental variation and differences in data quality and availability. It should be recognised that the cost effectiveness of employing different types of surrogates in other regions will be dependent on the current availability and quality of vegetation mapping, abiotic environmental and biological survey datasets within those regions. It should also be recognised that the most effective approach to reserve planning might be to use two or more surrogates in combination (e.g. vegetation mapping, species modelling and environmental domains) rather than employing only the best performing individual surrogate.

4. Evaluation of the performance of surrogates and modelling techniques elsewhere in Australia should be encouraged. The scope of such work should ideally cover a wide range of environments, spatial scales, biological groups and types of surrogates.

5. Further research should be encouraged into ways of refining surrogates to improve their performance as a basis for reserve planning. Areas of research particularly worthy of support include:

   - Refinement of surrogates to effectively deal not only with patterns of biological variation in environmental space but also with patterns in geographical space.

   - Refinement of abiotic environmental classifications and ordinations by using real biological survey data to test and calibrate measures of environmental distance and weights assigned to environmental variables.

   - Refinement of species modelling techniques to facilitate rapid processing of large numbers of species and incorporation of these models into reserve planning. The use of models for selected biological groups (or taxa) as surrogates for other groups also deserves further investigation.

   - Research into ways of improving the effectiveness of reserve planning by using two or more surrogates in combination.