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PREDICTIVE HABITAT MODELLING FOR FLORA AND FAUNA SPECIES IN THE SWAN REGION

Project 0169-0007

Draft Report prepared for:
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1. Introduction

Eco Logical Australia (ELA) was contracted by the Western Australian Department of Environment and Conservation (DEC) to undertake predictive habitat modelling for flora and fauna species in the Swan Region, Western Australia (Figure 1). This region included the whole of the Swan Coastal Plain Bioregion, and parts of the Geraldton Sandplains, and Jarrah Forest Bioregions.

Predictive habitat modelling can be used to provide an indication of the potential distribution and relative abundance/suitability of habitat for each species within a given study area. This information has a wide range of applications from guiding further survey effort to land management and planning, and applications with development control. Such information on their distribution in the Swan region is helpful for providing direction for future conservation efforts.

The project was designed for a staged approach, with a pilot study of four species to be modelled initially, followed by remaining species.

This report presents the preliminary results of modelling for two of the four initial species to be modelled. It briefly outlines the methods used, flags limitations of the project and suggests recommendations for future project work.

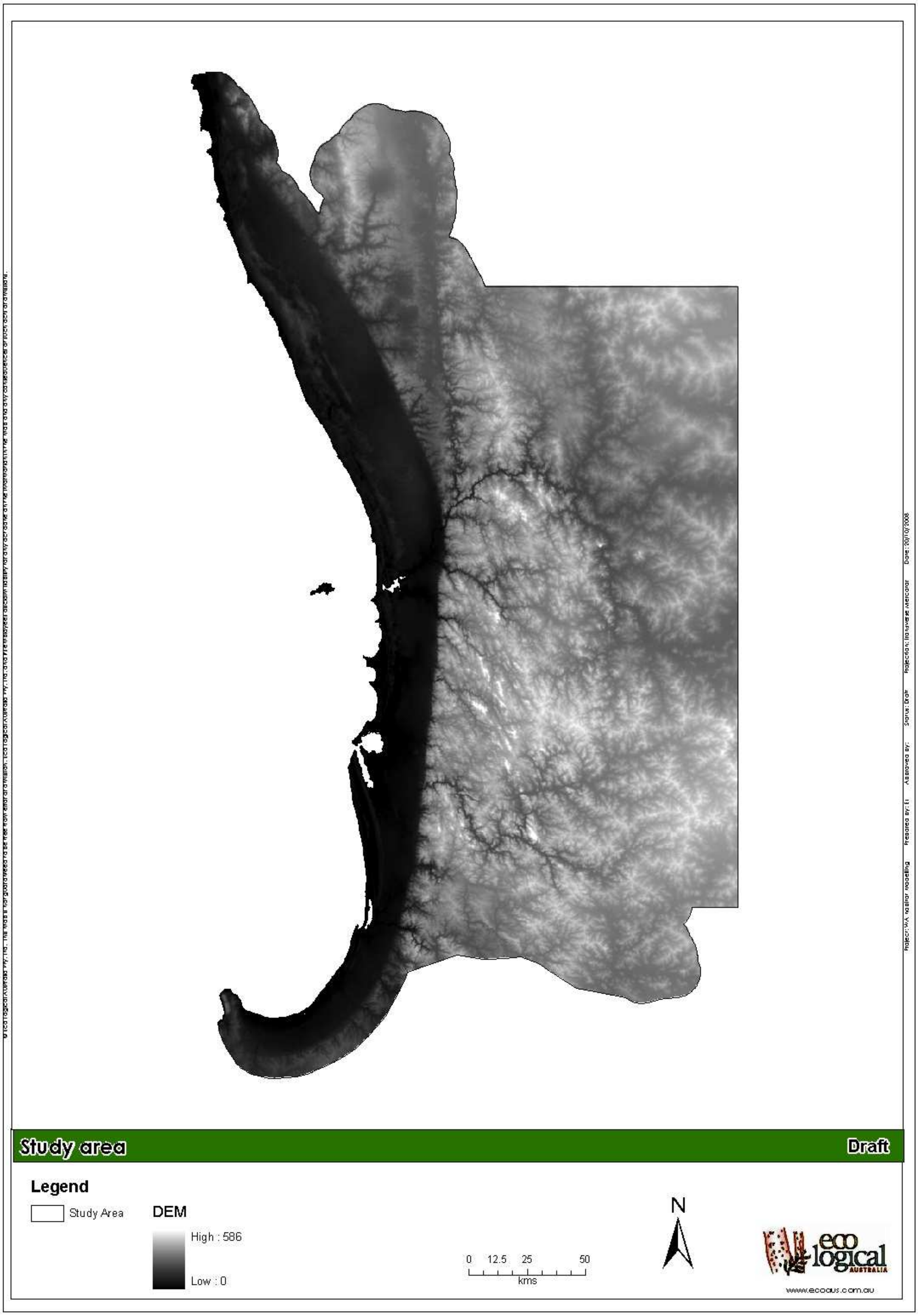

Figure 1: Modelling Study Area

2. Methodology

2.1 General Approach

Prior to conducting any habitat modelling, species record data and predictor layers were prepared. Data were provided by the DEC, and were prepared for modelling by ELA.

Once data was prepared, predictive habitat modelling took a two-stage approach. In the first stage, relationships between species locations and environmental variables were determined to identify potential drivers for species distribution. In the second stage, areas of potential habitat were predicted in geographic space based on the drivers for species distribution.

Models were evaluated for model strength. Poor models were re-run as necessary until the model that performed the best against evaluation criteria was generated (see Section 2.3 for details of criteria used to evaluate model strength).

Purpose-built software developed by Lehmann *et al.* (2002; 2004) was used to determine statistical relationships between species presence records and a range of spatial predictors (environmental variables covering terrain and topographic, drainage, soil and vegetation indices), and predict the distribution of potential habitat in geographic space. The software, known as "GRASP" (Generalised Regression Analysis and Spatial Prediction), was based around the use of Generalised Additive Models (GAM) in determining the relationships between species records and spatial predictors, and was used both as a module in the S-Plus Statistical Package, and as an extension in ArcView.

Generally, a step-wise procedure was used to select significant predictors. A starting model including all continuous predictors smoothed with 4 degrees of freedom was first fitted. The significance of either dropping smooth terms or converting them to a linear form was then tested using an analysis of variance (F-test). The minimum contribution for predictors was set to 5% and the maximum correlation between predictors was set at 75%.

A more detailed step-by-step breakdown of the modelling procedure is provided in the Appendix to this report.

2.2 Input Data

2.2.1 Species

Of the four species that were to be investigated as part of the first stage of the project, habitat modelling was undertaken for two species. These species were the Waxy-leaved Smokebush (*Conospermum undulatum*) and the Graceful Sunmoth (*Synemon gratiosa*). These two species were selected in preference to the other species due to their higher number of presence records relative to the other species, and available information on the habitat preferences of the species.

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2.2.2 *Environmental Variables*

Table 1 below shows the environmental variables compiled for the modelling procedure. Each variable was made up of a raster dataset with a 20m grid cell size and clipped to the modelling extent (study area as in Figure 1 above).

Two environmental variables that were also prepared, but were not used in analyses were flow accumulation and distance to coast. These variables were not used in analyses due to their large file sizes; ArcView was not able to process any files larger than 2GB, and files containing these variables were greater than 2GB in size.

Table 1 Environmental variables used for modelling

Data Category	Layer Name	Explanation of Layer
Terrain and Topographic	Dem	Digital elevation model
Terrain and Topographic	Slope	Slope derived from DEM
Terrain and Topographic	Aspect	Aspect
Terrain and Topographic	Top100	Topographic position 100m
Terrain and Topographic	Top250	Topographic position 250m
Terrain and Topographic	Top500	Topographic position 500m
Terrain and Topographic	Top1000	Topographic position 1000m
Terrain and Topographic	Rug100	Ruggedness 100m
Terrain and Topographic	Rug250	Ruggedness 250m
Terrain and Topographic	Rug500	Ruggedness 500m
Terrain and Topographic	Rug1000	Ruggedness 1000m
Drainage	Allstrm	Distance to waterway (all streams)
Drainage	Mjstrm	Distance to waterway (major streams only)
Soil	Acidity	Acidity
Soil	Perm050	Permeability 0-50cm
Soil	Perm150	Permeability 0-150cm
Soil	Salinity	Salinity
Soil	Wlog	Water logging
Soils	Wstore	Water Storage
Vegetation	Preveg	Pre-European Vegetation
Vegetation	Remveg	Remnant Vegetation

2.3 Model Evaluation

All final models produced were evaluated by assessing 1) the predicted distribution of the species, 2) validation and cross-validation statistics, and 3) the contribution of the variables (or predictors) to final models. These are described below:

- Distribution – the mapped prediction surface for final models produced were reviewed with regards to its match to recorded species location, locations and habitats selected, and knowledge of the potential use of such locations and habitat types;
- Validation and Cross-validation statistics – the correlation between the actual values and values predicted by the model (ROC test used), and the graph

shape for validation and cross-validation were reviewed to determine the strength of the final models. A strong model was one which had a high ROC value (close to 1) and a near perpendicular shape.

- Variable contribution and utilisation – the variables used in the model were reviewed for their contribution to the model (alone and within the final model) and their importance to the model (variable cannot be compensated by other variables if dropped from the model). The best models were determined based on the variable's perceived relevance and importance to determining species distribution.

A broad evaluation ranking of very high, high, moderate or poor was given to each model to represent the perceived strength in the model.

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3. Results

Habitat predictive maps for Waxy-leaved Smokebush and Graceful Sunmoth are shown in Maps 2 and 3, respectively.

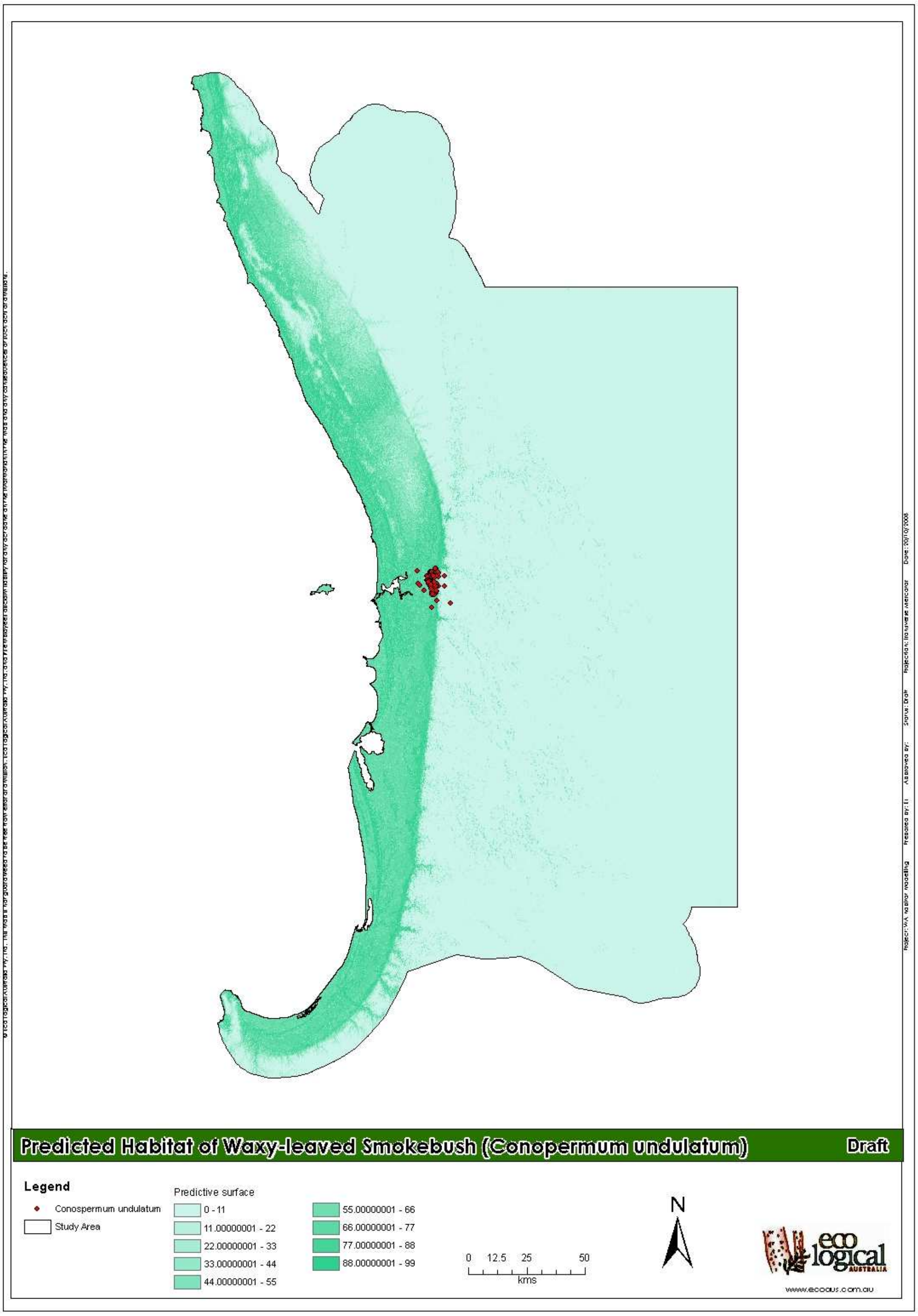

Figure 2: Habitat predictive map for Waxy-leaved Smokebush.

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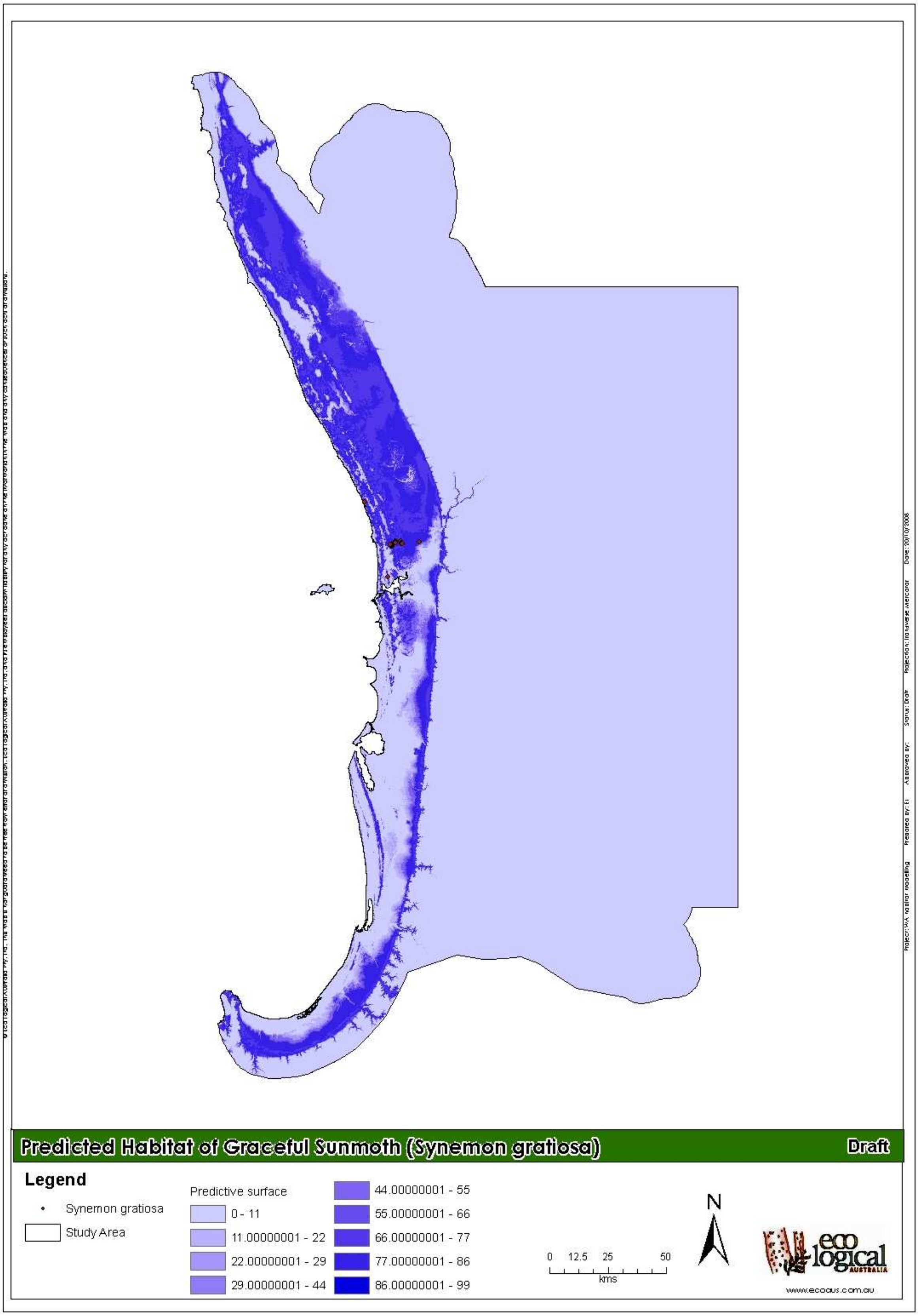

Figure 3: Habitat predictive map for Graceful Sunmoth.

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Table 1 shows the number of records used for the two species modelled, along with the final predictors in the model, and results of model evaluation.

Table 1: Summary of models for Waxy-leaved Smokebush and Graceful Sunmoth.

Species	Scientific Name	Records	Predictors in model	Model evaluation	Comments
Wavy-leaved Smokebush	*Conospermum undulatum*	155	top500, dem, rug500, aspect	High	High validation and cross-validation statistics. Distribution is a reasonable match to points
Graceful Sun Moth	*Synemon gratiosa*	25	dem	High	High validation and cross-validation statistics. Distribution is a good match to points

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4. Model Limitations

The models produced show areas of the landscape that contain potential habitat for Waxy-leaved Smokebush and Graceful Sunmoth. However, as for all models, these were based on the data that were input into the system. There may be other variables, such as weather variables (currently unavailable), that may better predict the potential habitat for the two species. Further, species presence records, at least for the Graceful Sunmoth, were limited to 25 records over a greater than 300km^2 study area. Thus, the models should be treated as indicative only, highlighting those parts of the landscape where there is potentially a higher probability of the species being present (or at least utilised during some part of its life cycle).

In addition to the models being limited by available data, evaluation of models was constrained by the paucity of information available on the species modelled. A large proportion of model evaluation is based on knowledge of species habitat preferences. Without knowledge of species habitat preferences, analysis of model strength must by necessity based less on the perceived relevance of predictors and more on distribution and validation and cross-validation statistics.

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5. Recommendations

Given that model evaluation relies in part on knowledge of species' habitat preference, and predictors are often entered into models based on the perceived relevance of predictors on determining species habitat, consultation with experts on the species will assist in producing models that better predict habitat. Therefore, ELA suggests that the next stage in this project include consultation with botanists familiar with Waxy-leaved Smokebush and Keighery's Macarthuria (*Macarthuria keigheryi*) and with entomologists familiar with Graceful Sunmoth and Native Bee (*Leioproctus douglasiellus*) (Keighery's Macarthuria and the Native Bee are the remaining 2 species to be modelled as part of the initial stage of this project).

In addition, more data on the locations of the species will play a role in modelling potential habitat. ELA understands that additional presence records are available for Graceful Sunmoth and Native Bee (Nicole Willers, DEC Conservation Officer; pers. comm.). This data should be attained before further habitat modelling is attempted as the data will assist in determining the drivers for species distribution, which will in turn drive the predictive surface produced.

6. Conclusions

Predictive habitat models have been generated for two of the four flora and fauna initial species to be modelled across the Swan Region, both of which are listed as threatened species under WA legislation.

Models generated for the Waxy-leaved Smokebush and the Graceful Sunmoth were both evaluated as high.

There were a number of limitations to the models produced. Evaluations were mainly based on distribution, and validation and cross-validation statistics, rather than knowledge of species habitat requirements. In addition, the model for Graceful Sunmoth was based on only 25 presence records spanning over a large study area. As such, ELA recommends that the next steps in the project include consultation with relevant experts. As well, ELA recommends that additional presence records for Graceful Sunmoth and Native Bee be attained and included in subsequent habitat modelling.

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7. References

Lehman A., Leathwick J.R. and Overton J.McC. (2004) GRASP v3.0 User's Manual. Swiss Centre for Faunal Cartography, Switzerland.

Lehmann A., Overton J.McC. & Leathwick, J.R. (2002) GRASP: Generalised regression analysis and spatial predictions, Ecological Modelling, 157: 189-207.

8. Appendix

Step-By-Step Breakdown of Modelling Procedure

The modelling procedure used was as follows:

1. Define the study area;
2. Generate environmental variables to cover the study area;
3. Collate records of species locations within the study area;
4. Undertake a data cleaning exercise on the species records in order to remove records that may bias the modelling procedure such as those with:
    a. A low recorded positional accuracy;
    b. Duplicate records;
5. Randomly generate pseudo absence records;
    - Pseudo absence sites were generated and joined to the presence sites (recorded species locations) for each species;
6. Analyse each environmental variable for all site locations:
    - Create a matrix showing a row for each species and a column for each environmental variable;
7. Analyse the entire environmental space of the study area by recording the full extent of each environmental variable;
    - Note the maximum and minimum value of each variable within the study area;
8. Initialise textual data into GRASP (running under S-Plus) and analyse;
    - A "Step-wise" GAM and an "F Test" was the model type used for each species. Minimum contribution was set to 5% and max correlation between predictors set at 75%;
9. Interpret and validate each model;
    - Review the outputs of the modelling procedure (graphs showing contributing variables selected, validation and cross-validation etc);
10. Output lookup tables from GRASP for selected models, which are then used in ArcView to generate prediction surfaces for each species (using an extension under ArcView);
11. Generate predictive surfaces in ArcView and evaluate models;
12. Adjust and rerun models where necessary.
    - Modelling was undertaken using an iterative approach for each species. That is, broad relationships were identified between species locations and habitat variables using a stepwise procedure (an automated procedure within the software that seeks to identify the strongest relationships). Initial "draft" models were further refined through the incorporation of additional variables and/or removal of others until what was considered the best model possible was generated.

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