Department of **Biodiversity, Conservation and Attractions**

GOVERNMENT OF WESTERN AUSTRALIA

Biodiversity and Conservation Science

Habitat suitability of *Varanus panoptes* – November 2023 update.

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Background

DBCA has identified *Varanus panoptes* (floodplain goanna or yellow-spotted monitor) as one of the species in Western Australia most at risk from the impacts of cane toads. As a top level predator in the ecosystem, these large goannas are both environmentally and culturally important. Mapping this species and predicting where they occur ahead of the cane toad invasion front is of vital importance to planning the mitigation of cane toad impacts on the species.

This project is developing a habitat suitability model for the floodplain goanna so that the DBCA Ecosystem Health Branch and Macquarie University researchers, along with other project collaborators, can prioritise areas for taste aversion training. It is important to know where significant habitat and thus populations are likely to occur in order optimise the location of the taste aversion training.

Progress on the development of the habitat suitability model

Over the last 18 months, work has focused on sourcing up-to-date observation records from the Museum, DBCA, Country Managers, Atlas of Living of Australia and industry data in BIO Dandjoo. In the areas to the south and west of the 2021 cane toad front, the number of observations and survey effort remains low although Country Mangers do have active survey programs in these areas (Figure 1.). Spatial data for the environmental variables has also been sourced and prepared and an initial model has been run for the wider study area. This is currently being reviewed. The outcomes of this review may include advice that bioregions or combination of bioregions should be modelled separately or that a model be developed for the sub-species *V.panoptes rubidus*.

Broad Habitat requirements

The team identified that the major habitat requirements of the species are:

- Access to water – the species require productive systems that have water and a range of food (e.g., insects, reptiles, frogs) and need moisture for breeding egg burrows.
- Soft loose soils that the animals can dig to burrow for breeding (approx., 3m in depth) and aestivate to avoid adverse conditions (approx., 1m in depth). Sandy soils and salt pans are suitable but not black soil plains (clay).
- Open topography and habitat are required to enable a line of sight to possible predators. Rugged and narrow areas are not preferred but *V. panoptes* can occur on the top of ranges if there is sufficient soil to depth as noted above.
- Vegetation types - Open savanna woodlands, open (not closed) forest, spear grasslands, dry sclerophyll forest, spinifex (southern areas).
- Climate factors and fire are not a determinant as the species will aestivate to avoid adverse temperatures or lack of food resources due to fire or poor seasonal conditions. However, it should be noted the model required for the cane toad project is to identify habitats and seasonal conditions where and when the species will be moving in the landscape and not aestivating.

V.panoptes can move up to 2km especially males outside the breeding season.

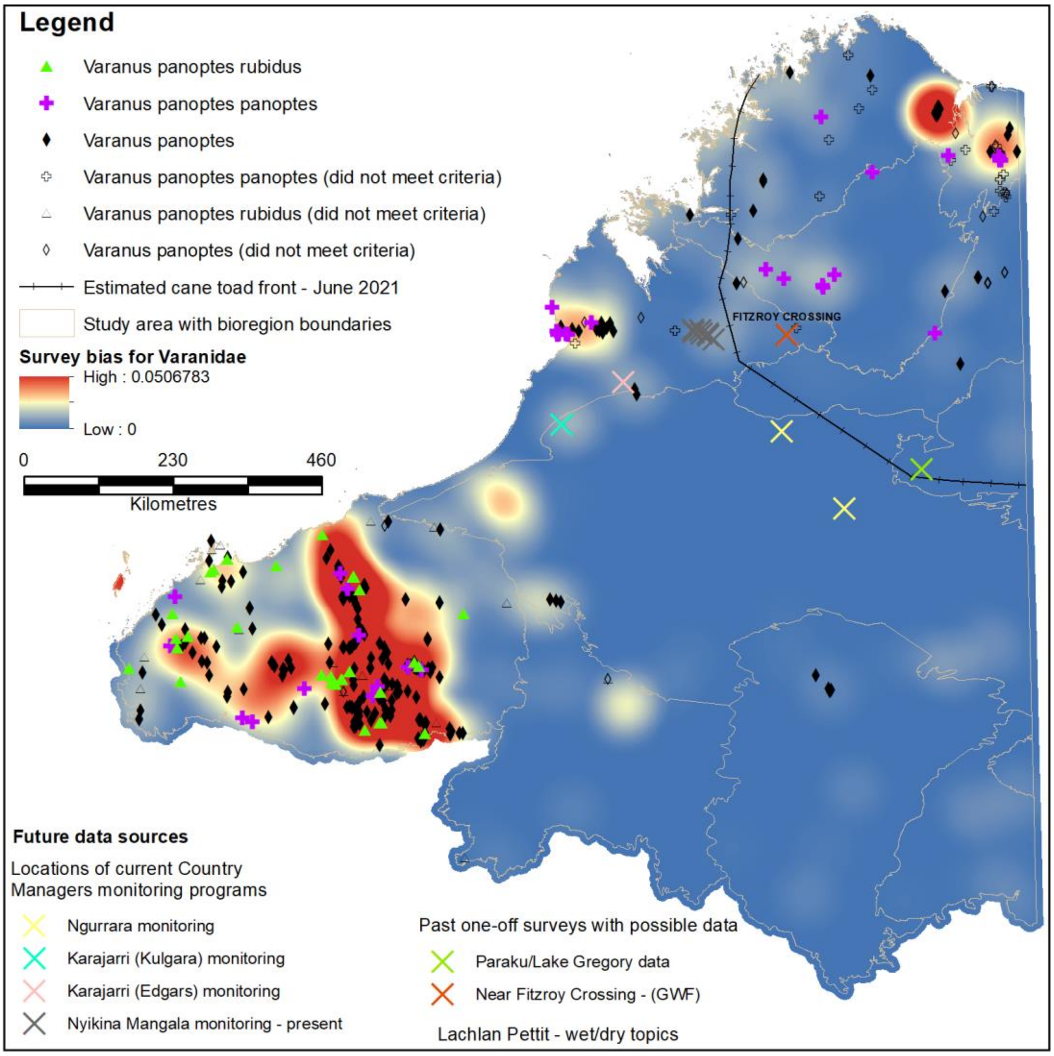

Figure 1. Occurrences of *Varanus panoptes* included in the modelling (filled). Occurrences recorded to sub-species have been symbolized. Those occurrences, from the ALA and Dandjoo, that did not meet the criteria for inclusion in the modelling are also displayed (no fill). Crosses mark locations where there is active monitoring by Country Managers or other studies where data may be made available to the project.

Modelling approach

The Maxent modelling approach was used and is a robust method when only species presence records are available. The modelling approach predicts habitat suitability by a finding a geographic distribution that is most uniform taking into account the limits of the environmental variables of known (presence) locations of the species.

V.panoptes records were sourced or downloaded and then cleaned and rarefied to minimise spatial autocorrelation. A total of 303 presence points were included in the model and a bias layer was used when selecting the 10,000 background points and a further 10,000 points were randomly selected from across the study area (Figure 1). Spatial environmental variables were identified that were related to the broad habitat requirements identified above (Table 1) and collinearity checks were undertaken with the variable most aligned to *V.panoptes* habitat requirements selected.

Maxent 3.4.1 (Phillips *et al*. 2006 and 2017) was used and implemented in R using the package SDMtune (Vignali *et al*. 2020). The modelling approach split the presence and background locations with 60% used to train the model, 20% to tune the parameters and 20% for testing. The training dataset was split into four cross validation folds using a checkerboard method that minimised spatial non-independence. Throughout the modelling stages, model performance was evaluated using the AUC. After the initial model run a jack knife test removed any other correlated variables. The model parameters were then tuned by doing multiple runs to identify the best parameter combination. A final jack knife test was done to remove variables with low importance. The train and tune presence and background locations were combined for the final model that was run using the tuned parameters.

Further technical details on the modelling process can be provided.

Model Results

Overview

The model had a moderate to high performance (AUC of train locations 0.84 and test locations 0.79) indicating it had a reasonable capacity to separate suitable and non-suitable habitat (Figures 2 & 3a). Areas of high suitability were in some coastal and inland waterways of the north Kimberley with the majority of the Central Kimberley, Ord Victoria Plain and Tanami bioregions being of moderate suitability. Most of the inland areas of the North Kimberley bioregion are of low suitability. The Dampierland bioregion has areas of high suitability along the northern coast but low suitability south and east of Broome including along 80-mile beach. In the Pilbara, areas of high and moderate suitability are located across both coastal and inland areas with only small areas of low suitability. This is perhaps indicating that the species can utilize broader habitats in the Pilbara or that the sub-species *V.panoptes rubidis* has different habitat preferences and this aspect is currently being reviewed. Both the Little Sandy and western Gibson desert have areas of moderate suitability with some occurrences recorded in the latter. There is some alignment between *V.panoptes* and cane toads and this area of moderate suitability could indicate that there may be a pathway for cane toads to invade south through this corridor and further investigation is required. The model rates the majority of the Great Sandy Desert, eastern Gibson Desert and Central Ranges bioregions as having low suitability.

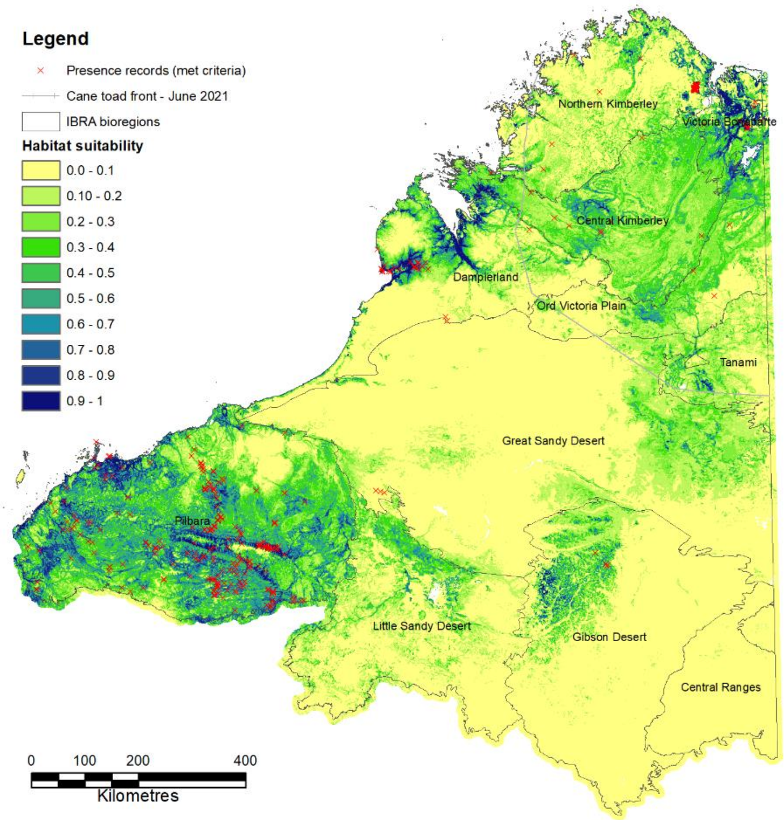

Figure 2. Final Maxent model extrapolated across the study area showing areas of high and low habitat suitability for *V.panoptes*. Values above 0.37 indicate suitable habitat. This threshold maximises the sum of sensitivity (proportion of presences that are correctly predicted to be present) and specificity (proportion of absences (background sites) correctly predicted to be absences).

As mentioned previously it should be noted that the restricted availability of presence points and bias in survey effort (Figure 1) means that there is a high degree of uncertainty in the model.

Environmental variables that contributed most were precipitation seasonality (BIO15), distance to water and proportion of sand at a depth of 0-5cm, distance to all waters, mean temperature of the warmest quarter (BIO10), depth of soil and distance to natural waters (Figures 3b & 4; Table 1). The response curve of BIO15 shows that its importance may be related to the spatial bias in the presence records (Figure 4) and we have sought feedback from the reviewers on this.

Observations from any future surveys can be incorporated into the database and the model re-run. This would likely greatly improve the model especially in those areas with low survey effort.

Detailed Model Outputs

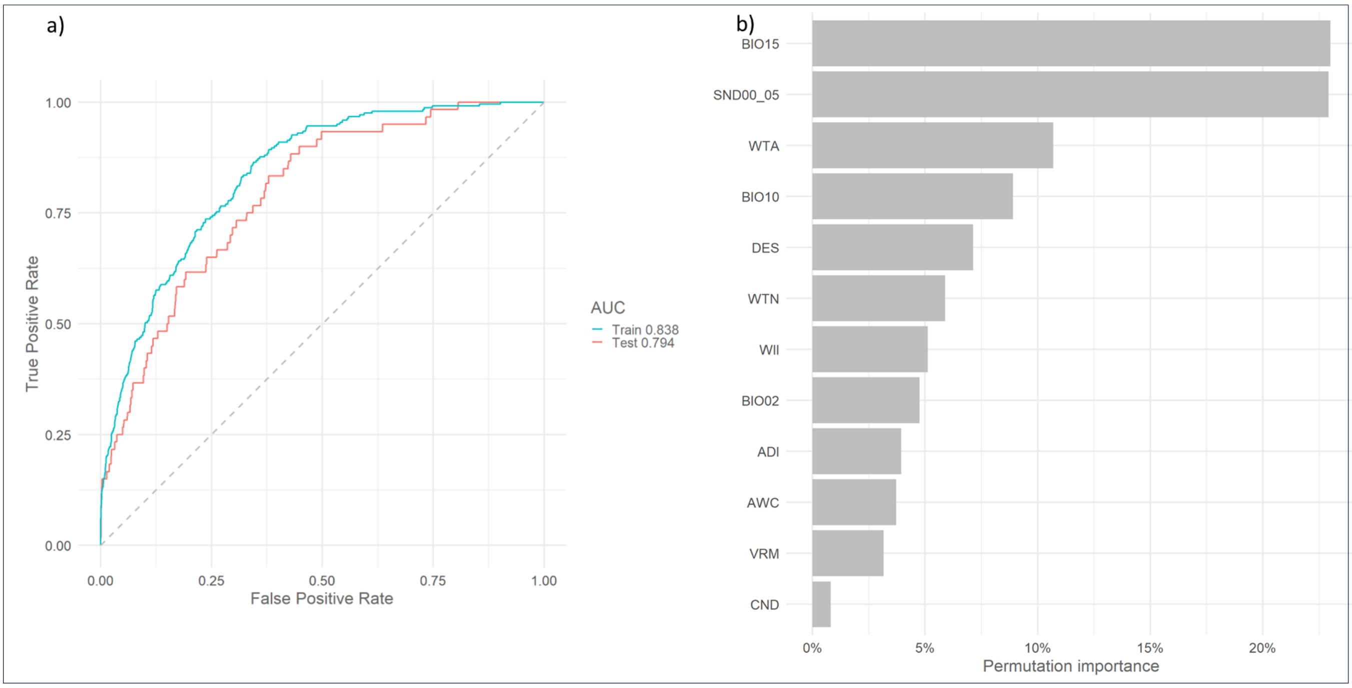

Figure 3. a) ROC plot for the final optimised Maxent model showing the AUC for the training and testing datasets; b) the contribution of each variable to the final optimised Maxent model based on permutation importance. This assessment of importance is done by randomly permutating (shuffling) the values of that environmental variable among the training points (both presence and background) and measuring the resulting decrease in AUC.

Table 1. Environmental variables included after initial collinearity checks were complete. Variables shaded in grey were selected for the final model and the % contribution provides an indication of the variable importance. Other climate, soil and primary productivity continuous variables were included in earlier model runs as were categorical soil and vegetation mapping. These will be considered again in subsequent model runs.

Code	Environmental variable	Habitat requirement	% Contribution to model
ADI	**Minimum monthly aridity index*.** The monthly ratio of precipitation to potential evaporation. A numerical indicator of the degree of dryness of the climate at a given location	**Climate/productivity**	**4.3**
BIO02	**Mean of the monthly Diurnal Range*** (ºC)	**Climate/productivity**	**2**
BIO03	**Isothermality*** Quantifies how large the day-to-night temperatures oscillate relative to the summer-to-winter (annual) oscillations	**Climate/productivity**	**R-HC**
BIO10	**Mean Temperature of Warmest Quarter*** (ºC)	**Climate/productivity**	**7.1**
BIO15	**Precipitation seasonality**	**Climate/productivity**	**19.7**
BIO16	**Precipitation of Wettest Quarter*** (mm)	**Climate/productivity**	**R-HC**
BIO20	**Annual Mean Radiation (Wm^{-2})**	**Climate/productivity**	**R-LI**
DES	**Depth of Soil (m)**	**Soil**	**8.7**
SND00_05	**Sand % at 0-5cm depth**	**Soil**	**12.4**
SND100_200	**Sand % at 100-200cm depth**	**Soil**	**R-LI**
SNDW0_100	**Weighted mean of sand (0-100cm).** The raw proportion data has been averaged over 4 depths (0-15, 15-30, 30-60, 60-100 cm's) and a weighting was applied according to the size of the depth class. The value of 16.67 represents 100% sand.	**Soil**	**R-HC**
SNDW0_200	**Weighted mean of sand (0-200cm).** The raw proportion data has been averaged over 5 depths (0-15, 15-30, 30-60, 60-100, 200-200 cm's) and a weighting was applied according to the size of the depth class. The value of 20 represents 100% sand.	**Soil**	**R-HC**
VRM	**Vector Ruggedness Measure.** A measure of terrain ruggedness	**Topography**	**2.4**
WII	**Weathering intensity index**	**Soil/Substrate**	**4.6**
CND	**Near surface conductivity (S/m)**	**Soil/Substrate**	**4.5**
AWC	**Available Water Capacity (%)**	**Access to water/productivity**	**4.9**
WTA	**Distance to all waters.** Distance to natural and man-made waters that are perennial or non-perennial water (m). Excludes saline areas and seasonally inundated areas.	**Access to water/productivity**	**26**
WTN	**Distance to natural waters.** Distance to natural perennial or non-perennial water (m). Excludes saline areas and seasonally inundated areas.	**Access to water/productivity**	**3.4**

*Bioclim variables are 30-year averages (1976 - 2005) centred on 1990

R-HC variable removed as highly correlated with another variable of higher importance

R-LI variable removed as had low importance.

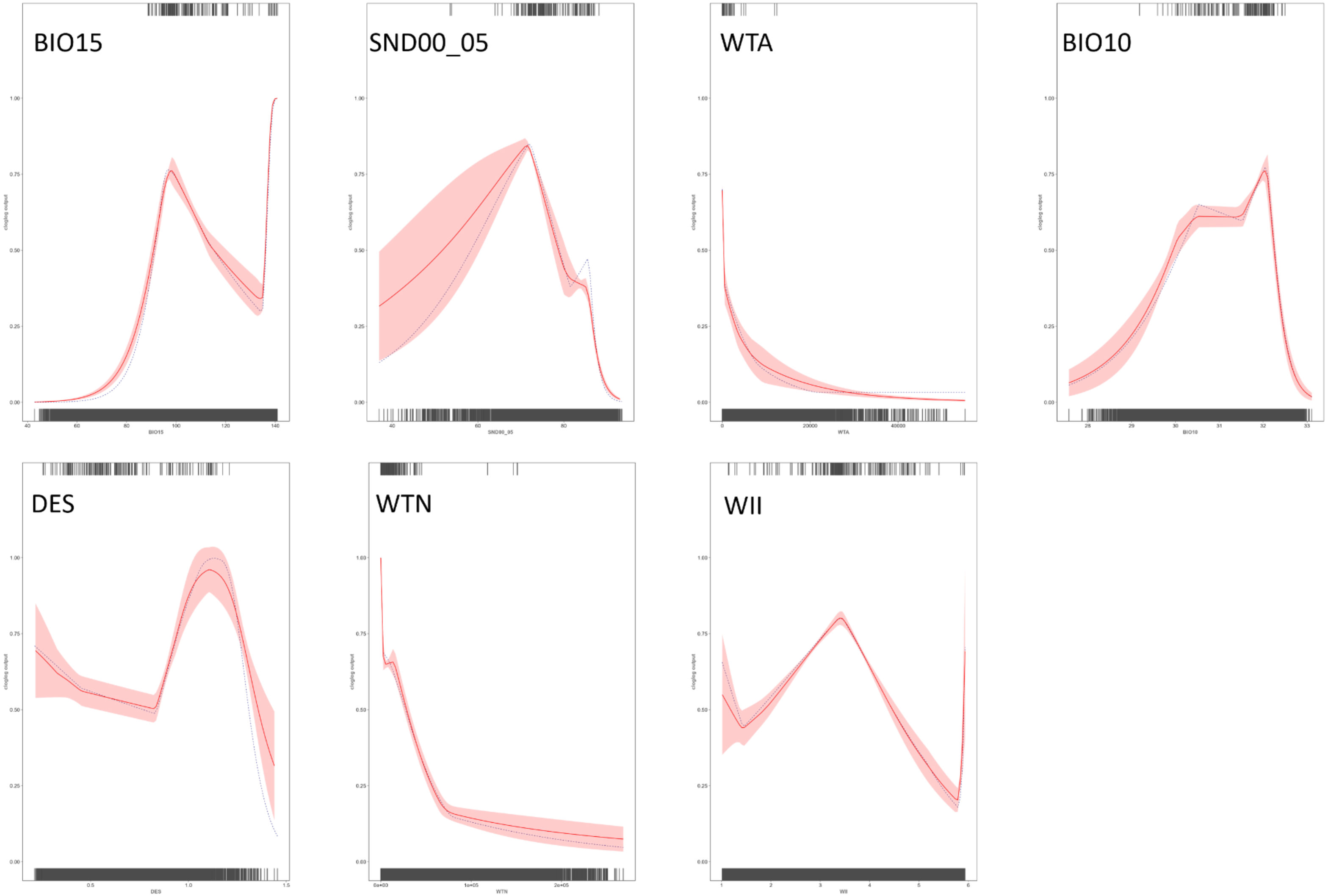

Figure 4. Univariate response curves for the variables included in the final optimised model. The red line is the mean across the four cross-validation folds and the shaded area shows one standard deviation interval. The dashed blue line is the final model. The tick points at the top are the presence locations and, on the x-axis, the background points.

References

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