NaturePrint – Habitat Distribution Models and Habitat Importance Models

Habitat Distribution Models and Habitat Importance Models inform biodiversity decisions and NaturePrint products.

Habitat Models are developed from species observation records and environmental variables. They estimate the distribution of habitat for thousands of Victorian flora and fauna species. They are used to guide investment, management and regulatory decisions to improve outcomes for biodiversity.

NaturePrint

NaturePrint is a suite of decision-support products and tools designed to help us make choices about what actions to take, and in which places, to protect Victoria's terrestrial biodiversity and plan for the future. The tools currently include:

- Habitat Distribution and Importance Models
- Strategic Biodiversity Values
- Strategic Management Prospects
- Specific Needs

Further information about NaturePrint, including information sheets, is available at https://www.environment.vic.gov.au/biodiversity/natureprint.

NaturePrint products can be viewed using NatureKit – the department's online biodiversity mapping and reporting tool: https://naturekit.biodiversity.vic.gov.au.

Habitat models

All plants and animals have environmental requirements and preferences that influence where they are found. These include the location of vital resources (i.e. food, shelter, nutrients), the occurrence of species they interact with, and how much they tolerate variation in these and other environmental factors. Species can vary substantially in terms of their resource requirements and their ability to adapt to different environments. Therefore, some species occur only in very specific habitat, whilst others can tolerate and thrive in a wide range of habitats.

Habitat Distribution Models

To appropriately inform land-use planning and biodiversity conservation effort, we need to know where different species might occur. Habitat Distribution Models (HDMs) are one of the NaturePrint tools that can help with this. HDMs collect and compare information on where a species has been recorded, and relate that data to environmental variables, such as soil, prevailing climate and topography. Sophisticated statistical and mathematical processes are then used to estimate the distribution of a species' habitat.

The information provided by HDMs is incredibly useful. It can help guide planning for activities such as fire management, conservation reserve management, infrastructure development, land-use planning, invasive species management, timber harvesting operations and more. HDMs can also direct survey effort where knowledge gaps exist. HDMs do not predict whether or not a species currently occurs in the habitat at a particular location. Many factors can influence whether a species is present in the habitat at any given time, including: biogeography; size of the habitat patch and distance from other suitable habitat; natural disturbance cycles or historic catastrophes; seasonal factors; and the impact of predators or disease.

HDMs have been created for thousands of Victorian flora and fauna species, including most of Victoria's vertebrate fauna, vascular flora and some rare or threatened invertebrates.

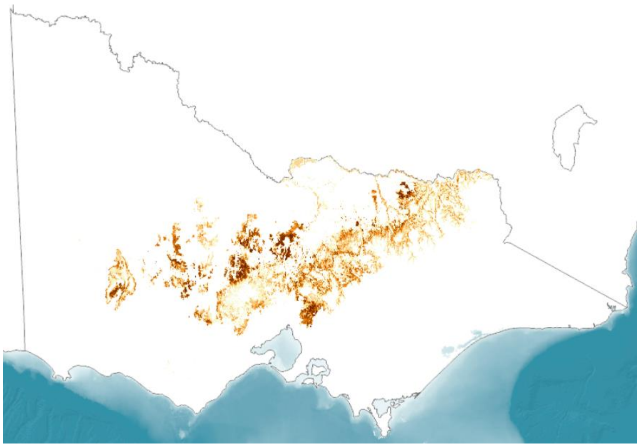

Figure 1: Habitat Distribution Model for the Brush-tailed Phascogale *Phascogale tapoatafa*. Darker areas indicate areas with higher likelihood of habitat for this species.

Habitat Importance Models

Conservation decision-making processes are influenced by where species habitat is likely to occur, and by the relative importance of the habitat for the species. The relative importance of habitat in different places is determined by the amount of habitat available, its condition, and how much the habitat is connected across the landscape. Some species have a greater chance of survival in larger or more well-connected natural landscapes than smaller and less connected remnants.

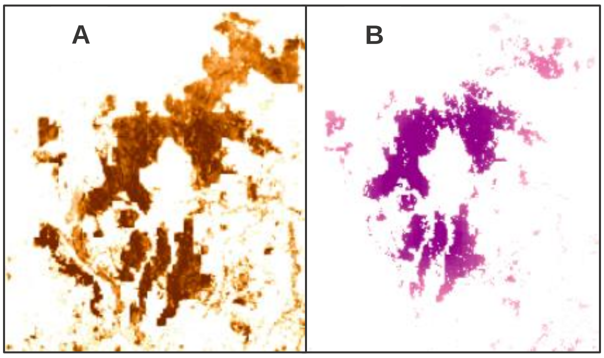

Figure 2: Habitat Importance Model for the Brush-tailed Phascogale (B) compared to the Habitat Distribution Model (A) for the same area. The darker areas indicate the habitat most likely to be of high importance (including current habitat and areas that could be re-established).

Habitat Importance Models (HIMs) reflect this variation in the ability of species to access substantial areas of habitat and to move across the landscape. HIMs indicate which patches of habitat may be relatively more important to a species' persistence than others (e.g. Figure 2b).

Habitat importance information is essential for regulatory and investment decision making as it shows which areas are most and least important for individual species. Habitat importance modelling also provides the starting point for thinking about historic impacts on occupancy of suitable habitat, and potential future scenarios for species under climate change.

Common uses of habitat models

Habitat distribution models and habitat importance models provide a comprehensive view of species distributions across Victoria, and therefore can provide answers to a number of important conservation questions. For instance, HDMs and HIMs can answer questions with a species-specific lens, for example:

- Where is the Brush-tailed Phascogale's likely habitat?
- What are the most important areas for providing Broad-toothed Rat habitat?

The models can also be combined to provide information on biodiversity as a whole, using a multi-species approach, for example:

- Where are the areas of highest biodiversity value in Victoria?

Taking this concept further, another NaturePrint product, Strategic Management Prospects, uses a combination of inputs including biodiversity values (informed by HDMs), threats, management responses and indicative costs, to answer questions related to cost-effective management, such as:

- Which actions, and where will make the most cost-effective difference for biodiversity in Victoria?
- What are the most cost-effective places for managing a particular threat in Victoria?

For most purposes, it is recommended that habitat models, rather than just species records from the Victorian Biodiversity Atlas (VBA), are used to guide decision making. Although field observations are a critical input to understanding species distributions, extrapolation of records to models significantly improves decision making. This is because:

- Available records are typically a very limited and unequal representation of actual habitat. Rigorous surveys of the entire range of a species for individual decisions are too time-consuming and expensive.
- Models provide a transparent and consistent view of what is likely habitat. They are less influenced by

timing of a particular site assessment, skill levels of a particular field assessor, or whether a species is present at a point in time.
- Models can take account of bias in the data (e.g. most bird records are close to urban areas).
- Models allow us to consider any issues associated with particular species up front, so expectations in regulatory and investment processes are clearer.

For some species, we have so few observations that it is not possible to generate a full HDM or HIM. In these cases, either buffered points or selected vegetation classes where the observations are recorded are selected and cut to the landscape area to reflect the specific location of the species population.

Use of models in NaturePrint analyses

HDMs form the basis of analyses for the NaturePrint tool Strategic Management Prospects (SMP). This tool provides guidance about which actions in which places could deliver maximised biodiversity outcomes, taking cost-effectiveness into account.

HIMs and HDMs are used in the development of another NaturePrint tool – Strategic Biodiversity Values (SBV). SBV provides a view of where the highest biodiversity values in Victoria are located and how close together they are grouped. As HIMs incorporate information on connectivity and species' ability to disperse through landscapes, they are ideal for informing this analysis. See more information about SMP and SBV on the NaturePrint website.

Use of models in Native Vegetation Regulations

Since 2013, HDMs have informed native vegetation regulations. The regulatory framework requires some specific adaptations to the models. For this purpose, the HDMs have been thresholded as a way of further discriminating habitat likelihood. For each species group, or at an individual species level, a "threshold" (numeric cut-off) is derived through mathematical methods, and sometimes with expert judgement, to differentiate higher scores as being habitat. Areas with scores below the threshold are removed from the final map, so it is clear what the Department deems to be habitat or not (e.g. Figure 3). Additionally, the models are clipped to areas that currently support native vegetation. More information about the biodiversity tools for native vegetation regulations is on the Native Vegetation Biodiversity Information Tools web page.

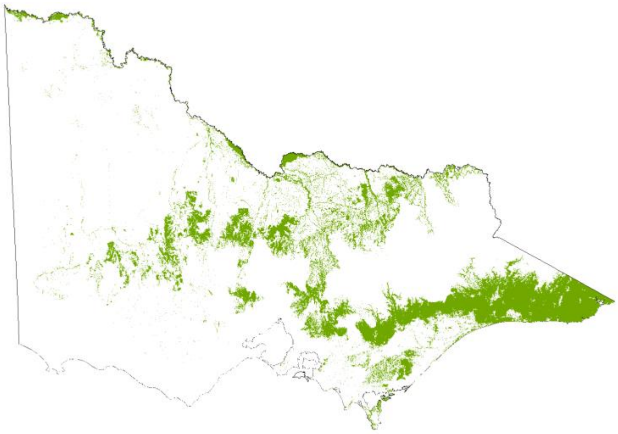

Figure 3: Habitat distribution model (thresholded and clipped to native vegetation extent) for the Lace Monitor *Varanus varius*. The green areas indicate current likely habitat.

In contrast, the HDMs used in SMP are not thresholded or clipped as strongly as the Native Vegetation HIMs. The SMP HDMs can therefore represent habitat where there is lower likelihood of the species occurring (including where the species may have been lost), but where it could occur again in the future if the habitat is restored through management actions or the species is translocated back to a site where it once occurred.

Building habitat models

Overview

The modelling process examines the environmental features where a species has been found (recorded as present in the VBA and with sufficient locational accuracy) and extrapolates beyond the known locations to other areas with a similar combination of environmental features. They identify not only the current known species distribution but also potential habitat. Where potential habitat is identified based on the right type of environment, but in a geographic area considered unlikely to have been used by the species pre-1750, this is masked out of the model.

Species' habitat distribution models are based on Victorian species observation records from the VBA that have been collected since 1980. These models also use interstate species records from BirdLife Australia, and South Australia and New South Wales government databases. The inclusion of interstate species records ensures that natural ranges are appropriately considered. This practice has markedly improved the habitat predictions within Victoria.

These species records are then related to environmental features such as rainfall, temperature, terrain or soil type, which may help to predict how a species is distributed across the landscape. We used environmental predictors, resolved to 75 metre pixels, that are mapped comprehensively across the whole of Victoria and beyond (covering much of south eastern Australia). Predictor variables include gridded climate data, an independent data set of radiometric data (a useful surrogate for soils and regolith), and a range of variables derived from digital elevation models illustrating landscape features (e.g. terrain wetness, duration of solar radiation and height above water).

Climate change

Climate change will re-arrange many habitat and species distributions over time. Although changes in climate envelopes can be modelled, it is unclear how much species will be driven, or able, to track these changes. Additionally, stochastic disturbance events (such as wildfire) will change in frequency and severity and this will influence occupancy of habitat in difficult to predict ways. For these reasons, habitat modelling does not yet incorporate species-specific responses to future scenarios. We will continue giving attention to current habitat, including refugia, to provide a strong base for species as they adapt to emerging circumstances.

Absence data

The modelling process uses the locations where the species has been recorded, but also works best if it is known where the species does not occur – that is, the species is probably ‘absent’. A process has been developed to randomly allocate over one million pseudo-absence records across Victoria. Allocating these pseudo-absence points in a stratified, random process allows for increased model performance despite a lack of true absence data.

Sampling bias

Some species have been surveyed disproportionately across their range. For example, some species are recorded numerous times in particular regions of the state but rarely from other regions. This might reflect the actual distribution of the species, but it is sometimes due to other reasons such as how easy it is to get to locations and how many observers are looking.

Sampling bias has the potential to skew the HDM towards the area with many records and misrepresent the true species’ distribution. We reduced this problem by stratifying the location data for a species across its geographic range and subsampling (with replacement) the species’ presence records. We did this iteratively to construct 50 separate models. The HDM that we use is really an average of these 50 models.

Estimating uncertainty

Uncertainty is a statistical concept that describes how confident we are in a model. We repeated the subsampling routine (described above) 50 times to build 50 separate models for each species. We then calculated the average of the models and its variance (a measure of how far the whole population of models was from the average) for each species each as separate spatial models. Those species’ models with a large variance are more uncertain than those with a small variance. Identifying uncertainty in this spatial way means we can clearly see where improving our data will make the most difference to our decisions.

Continuous improvement

We are committed to a continuous improvement approach, which enables the NaturePrint products and tools to be updated and refined as further data, computational power, research and modelling methods become available. This approach means biodiversity impacts of the 2020 fire season will be included in the analysis for SMP Version 2.0. And in 2019, around 50 people provided feedback on around 200 species HDMs using an app designed for this process. These updated HDMs were included in SMP Version 2.0.

Everyone can contribute to the improvement of the NaturePrint tools. For example, by submitting species records to the VBA which is a key source of information for NaturePrint. Visit the Victorian Biodiversity Atlas web page for more information. NaturePrint products have a version number to identify the currency of each product.

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Accessibility

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