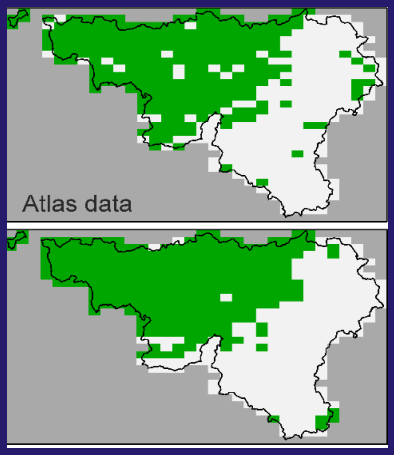
Hybrid SDMs - Accounting for both environmental and spatial aspects in species distribution models

DATA ANALYSIS



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Overview

Species distribution models (SDMs) predict the potential distribution of a species based on the characteristic fine-resolution environmental conditions in which the species was found. Such niche-based models usually ignore any spatial aspects (e.g., dispersal limitation, spatial autocorrelation) that may affect the species distribution pattern. Conversely, down-scaling models predict the proportion of fine resolution cells in which a species should occur based on geometrical aspects in the species' coarse resolution distribution patterns alone. However, downscaling models do not account for environmental heterogeneity and any aspects of the species' preferred niche. Thus, our aim was to develop a set of hybrid models that predict species distribution at various grains and extents, while accounting for both environmental and spatial aspects. To meet this aim, we developed a set of 4 hybrid models that differ from one another in the way they modify the SDM's **Probability of Occurrence (PoO)** map, in their emphasis on the occupancy predicted by downscaling, and in the way they translate the continuous PoO map to a binary **Presence/Absence (P/A)** map (Table 1).

Table 1. Main properties of the hybrid models developed by UnivLeeds under task 3.3 of EUBON.

	Moving Windows	Top X	TopDown PoO	SpaNiche model
Modify SDMs PoO map?	yes	no	yes	no
Utilises downscaling predictions?	no	yes	yes	yes
Thresholding method	Single threshold that optimizes fine-scale accuracy	Threshold that matches the predicted prevalence	No threshold	Single threshold that balances fine-scale accuracy and spatial consistency
Number of occupied cells in P/A output	Threshold dependent	As predicted by the downscaling models for the finest resolution	As predicted by the downscaling models at all resolutions	Threshold dependent

Expected advantages

1. **Increased accuracy:** predicting species real distribution pattern, and not the potential distribution.
2. **Multiple scales:** distribution is predicted at various spatial resolutions that may be more relevant to conservation and management.
3. **Flexibility:** a set of 4 models, each with different assumptions, emphasis and data requirements.

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Applicability

R scripts for all models are available as supporting information of Deliverable 3.2 and can be provided upon request. Future plans are to include the codes in the R package 'downscale,' developed by the University of Leeds, as part of Task 3.2 (see Deliverable 3.1). Similar to other SDM methods, all 4 hybrid models require fine-scale occurrence data and a set of environmental variables to fit the SDMs. Atlas data can be provided independently or can be created from the fine-scale occurrence data, using the 'downscale' package.

Potential users

Species distribution models are the main tool available today to predict species distribution pattern at fine resolution over wide extents. As the models produce a more realistic distribution than regular SDMs, they are mostly suitable for reporting on status and trend. They are less suitable for applications that use SDMs to predict potential locations in which the species may be survive, but are not currently occupied. The main users are those familiar with other SDM methodologies, while the end-users are decision-makers that require species distribution patterns for reporting and management.

Case study

We have applied the models to 87 bird species from Wallonia (Belgium). Examples of outcomes for one species (the yellow wagtail, *Motacilla Flava*) are given in Figures 1 and 2 below. For this species, the 'Moving Windows' method and the 'SpaNiche' model resulted in similar fine-scale accuracy, yet increased coarse scale accuracy relative to the original SDM. The 'Top Down PoO' and 'Top X' methods performed poorly, mainly since the downscaling models predicted very low numbers of occurrences (see Figure 2).

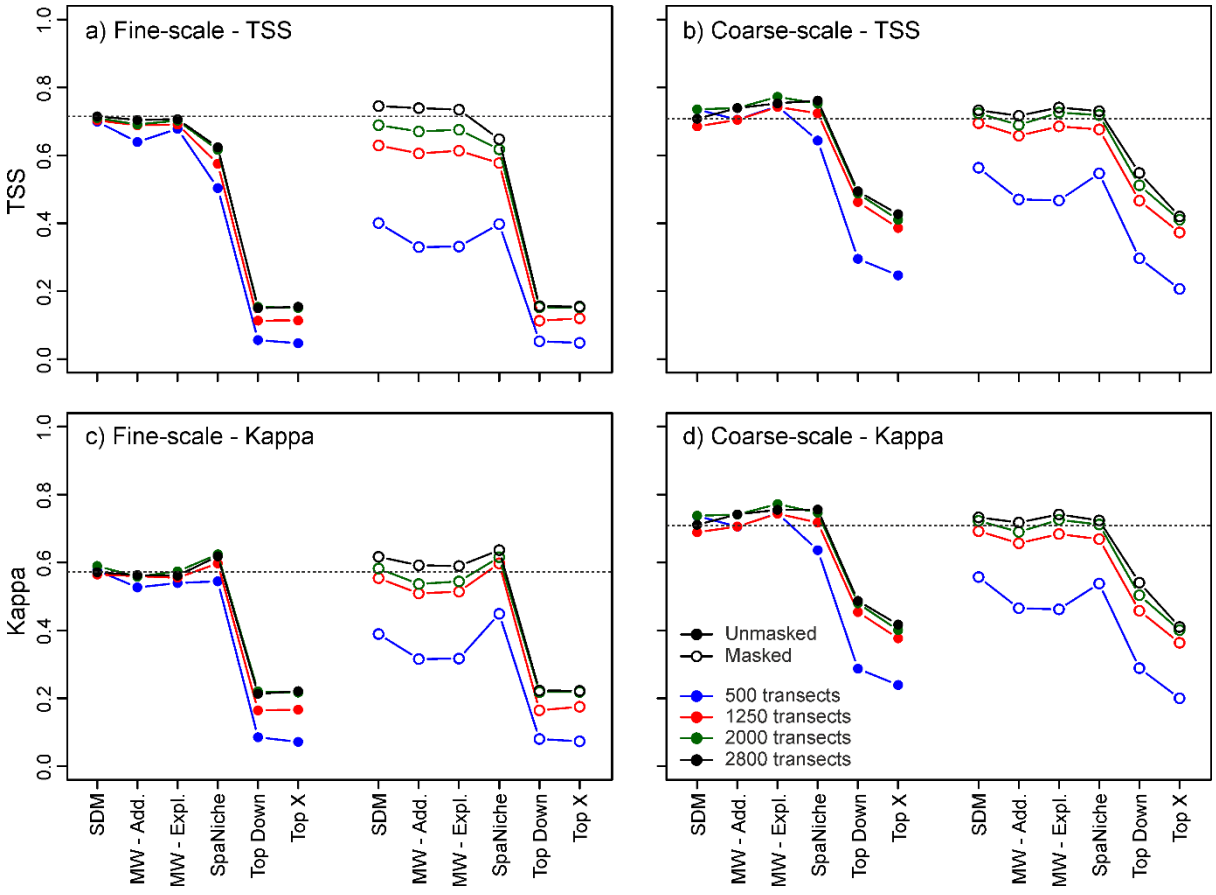

Figure 1. Comparison of the fine scale (a, c) and coarse scale (b, d) performance of all models based on the True Skills Statistics (TSS, a, b) and Kappa statistics (c, d). SDM: the original SDM; MW – Add: the Moving Window SDM when adding the windows PoO to the original PoO, MW – Expl: the Moving Window SDM when adding the windows PoO to the raw explanatory variables. See Deliverable 3.2 for further details regarding atlas masking data preparation and analysis.

Figure 2. The predicted presence (green) / absence (white) map at the 1×1 km (left panels) and the 5×8 km (right panels) resolutions for all unmasked models, the transect data (red = presence, black = absence) and independent atlas data. See Deliverable 3.2 for details.