Using Dempster-Shafer's evidence theory for species distribution modelling

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Abstract: Conservation managers rely on the knowledge of experts where information describing species distribution is scarce or unobtainable. However, experts' knowledge is always subject to uncertainty and accounting for this uncertainty into a modelling procedure poses a challenge. We propose using the Dempster-Shafer Theory of Evidence (DST) to accommodate knowledge uncertainty, and assess how this affects the performance of species distribution models. We applied DST to model the distribution of a well-known, and a poorly-studied raptor species in Spain. We invited experts to form a knowledge domain, and asked them through online questionnaires to express their knowledge on the habitat of the target species by assigning a probability value for a given environmental variable. Experts were also asked to acknowledge their confidence level on the assigned probability values. Then we calculated evidential belief functions and combined them using Dempster's rules of combination. We evaluated and compared the calibration and discrimination capacity of the DST models with two other conventional inductive models. The DST models yields similar results to conventional inductive methods for both species. Although the habitat of the well-known species was well-discriminated, DST models were generally underestimating the habitat favourability. In contrast, the models for the poorly-studied species were well-calibrated though the discrimination capacity remained low. Our proposed approach offers a practical alternative where knowledge of a species' geographic distribution is needed, and the distribution data is not sufficient. The particular strength of the developed approach is that it explicitly accommodates knowledge uncertainty. It also provides a framework to propagate and aggregate uncertainty, and it capitalizes on the range of data sources usually considered by an expert.