Comparison of density estimators in coastal populations using a modelling approach

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The earth is facing a biodiversity crisis and coastal ecosystems like mangroves, coral reefs and seagrass beds are severely declining in spatial extent and composition (Duke *et al.*, 2007; Stone, 2007; Cressey, 2009). In this light, the assessment of these communities and their biodiversity becomes increasingly important. Reliable estimates of population density and related parameters form an integral part of such studies, because they allow the detection of changes in species composition and consequently the conservation of endangered ecosystems.
Different methods have been used to obtain population density estimates of non-motile organisms. They are based either on counting the individuals in an area (plot-based) or on determining the distance between them (plot-less) (Krebs, 1999). While plot-based methods are robust and provide good estimates when applied to populations with different patterns, they are labour intensive. Plot-less estimators, on the other hand, are less time consuming, but often heavily biased (Magnussen *et al.,* 2012). Many researchers continue to use plot-less methods, even though very high errors have been reported (Hijbeek *et al.*, 2013). It is thus timely to device tools to help in the decision about the optimal density estimation methods for different study systems.
A model was written in the individual-based modelling language NetLogo (Khan M.N.I., Gherraz H., Grüters U., Dahdouh-Guebas F., unpublished results). It allows the user to create a virtual population with different configuration possibilities for point patterns, diameter distribution, species composition and zonation. It includes a set of estimation methods, and the option to choose between sampling designs and sizes. The model calculates the true density, area and frequency and additionally provides their estimation as obtained by the different methods. It was designed considering especially coastal ecosystems with their distinct zonation, complexity and difficulty of access. After a pilot study in the field, the user can rebuild the ecosystem in the model and use it to find the best estimation method in terms of accuracy, precision and efficiency for the respective study area.
In the on-going project, we will further develop the model (1) to include an option to either calculate the sample size based on a least accepted error or calculate the error based on a predefined sample size, and (2) to calculate the efficiency of each method. The sampling effort, which is usually assessed based only on common sense, will be estimated as a function of the number of individual measurements executed and the distance covered between them. The upgraded model will be rigorously tested for a number of scenarios comprising different configurations of the input parameters. The outcome of this study will be a catalogue of indications for density estimation methods in populations with different patterns, considering especially the particularities of coastal ecosystems.

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