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A GLMM approach for combining relative abundance surfaces

Spatio-temporal maps of animal density or relative abundance are fundamental to many applications in conservation and ecology.

There are often a number of data sources to inform species maps, including citizen science monitoring programs, geolocation data from satellite-tagged animals, and formal scientific surveys. In these cases, it may be desirable to come up with a single map integrating all data sources.

We introduce a two-step method for combining inference about relative abundance maps using multiple data sources. Log-scale relative abundance surfaces are first estimated from individual data sets, and resultant surfaces are then treated as ``data'' within a generalized linear mixed model framework with a common mean.

Using simulation, we show that our approach frequently outperfoms other approaches, including basing inference on a single surface, or taking a simple arithmetic mean (although the arithmetic mean performs well when there are few surfaces).

We demonstrate our method using citizen science and satellite-tracking data of Steller sea lions in Alaska. In this case, relative abundance surfaces consisted of an effort-adjusted map developed from platform-of-opportunity sightings and a utilization distribution developed from geolocation records. Resulting integrated surfaces represented a compromise between single-data source predictions.

Our approach should be useful for ecologists seeking to reconcile alternative species distribution maps, particularly in cases where individual surfaces are prone to bias or when there is no obvious common currency (e.g. point process) for a fully integrated analysis.