

Integrating multiple data sources for species' distribution models to evaluate management effects on focal bird species

Combining multiple sources of information with theory-inspired models and biological applications can increase the temporal and spatial scale of inference to answer conservation and management questions and increase efficiencies in data collection. Data integration methods for species' distribution models (SDMs) combine both structured (i.e., presence-absence surveys) and unstructured (i.e., volunteer-surveys) data. Most applications of data integration for SDMs have focused on conservation questions, with few applications to management. With management applications, focal species are primarily selected based on habitat relationships aligned with desired resource conditions and secondly based on feasibility in monitoring population trends. Insufficient detections with focal species are possible in monitoring programs, especially when species are rarer on the landscape due to limited habitat, low population size, or both. Innovative statistical approaches to integrating such data sources with SDMs can increase inference with rare focal species. We use a case study to illustrate differences in occupancy precision gain using data integration with SDMs of focal forest bird species that are comparatively rare (Ruby-crowned Kinglet [*Regulus calendula*]) versus common (Grace's Warbler [*Setophaga graciae*]) within a National Forest in the United States. In our application, we consider the temporal and spatial mismatch in sampling effort and observation data when integrating a novel set of data sources from eBird and Integrated Monitoring in Bird Conservation Regions. This approach could inform broad scale monitoring efforts of focal species in response to management actions and illustrates the potential of partnerships with volunteer-based organizations for broad monitoring efforts to increase data collection efficiencies and shared stewardship of public lands.