Extreme uncertainty and unquantifiable bias do not inform population sizes

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Species-specific population estimates are fundamental for many aspects of ecology, evolution, and conservation, yet they are lacking for most species. Aiming to fill this gap, Callaghan et al. (1) estimated global bird population sizes by modeling the relationship between eBird reporting rates and independent estimates and extrapolating globally. While we applaud their intention, we caution that their modeling framework is prone to yield extremely uncertain and biased estimates that cannot support robust inferences about species abundance distributions or other applications in ecology, evolution, or conservation (1, 2).

Their methods yield extremely large posterior uncertainties for total global bird abundance (3.9 billion to 2,080 billion; figure 2 of ref. 1), and 96% of individual species had posterior uncertainty spanning three or more orders of magnitude. Glaucous Gull (*Larus hyperboreus*) was listed as the fifth-commonest bird globally; it is difficult to be confident in this conclusion given that the 95% credible interval (CI) for Glaucous Gull overlapped the CIs for ∼67% of all bird species. This uncertainty in species ordering makes it impossible to use these estimates for reliable conservation prioritization as suggested (1).

The tremendous uncertainty associated with the estimates of population size results from the inadequacy of the 10 measures used to account for imperfect detection of birds in eBird data (1), for which there is extreme inter- and intraspecific variation in the observation process across regions, time, and habitat (3). eBird reporting rates also depend heavily on species' overlap with the activity of eBird users, which also varies by region, time, and habitat.

In addition to high uncertainty, the approach also led to biased population estimates for many species. Abundance estimates (1) fell outside minimum–maximum ranges provided by BirdLife International for 81% of the 2,423 species with available estimates (27% below the minimum, 54% above the maximum) (4).* Even the large uncertainty intervals repeatedly failed to cover known true values. For example, Swift Parrot (*Lathamus discolor*), which

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was recently assessed at 280 individuals (5), had a CI from 4,520 to 40 million (1). Spoon-billed Sandpiper (*Eurynorhynchus pygmeus*) has a population size of 490 individuals (95% CI 360 to 620) (6) but had a CI from 6,050 to 47 million (1). San Andres Vireo (*Vireo caribaeus*), used in model training with a population size of 2,500 to 10,000 mature individuals (4), was estimated as extinct (1).

Regional differences in reporting rates create bias, because, as noted by Callaghan et al., the 7% of species used to train the model were heavily biased toward Europe and North America (1). Density imputation based on spatially uneven calibration estimates biases the population estimates to an unknown and inestimable extent, with downstream influence on the shapes of species abundance distributions and ecological conclusions.

For species with sufficient data quantity and quality, citizen and community science data can produce reliable density estimates (3), and methods for such analyses are constantly improving (7, 8). However, no method currently exists to estimate global population sizes across species while accounting sufficiently for known sources of variation in eBird reporting rates. Meaningful global population estimates would represent a tremendous advance for ecology, evolutionary biology, and conservation but will require considerably more nuanced analysis of globally available data.

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