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Author for correspondence:

Kelsey K. Graham

e-mail: kelsey.graham@usda.gov

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A century of wild bee sampling: historical data and neural network analysis reveal ecological traits associated with species loss

Kelsey K. Graham¹, Paul Glaum^{3,4,†}, Joseph Hartert³, Jason Gibbs⁶, Erika Tucker^{7,8}, Rufus Isaacs² and Fernanda A. Valdovinos³

¹USDA-ARS-PWAPollinating Insect Research Unit, Logan, UT 84341, USA

²Department of Entomology, Michigan State University, East Lansing, MI 48824, USA

¹Department of Ecology and Evolutionary Biology, University of Michigan, Ann Arbor, MI 48109, USA

⁴Department of Environmental Science and Policy, University of California, Davis, CA 95616, USA

⁵Waterborne Environmental, Leesburg, VA 2017S, USA

⁶Department of Entomology, University of Manitoba, Winnipeg, Manitoba, Canada R3T 2N1

¹Milwaukee Public Museum, Milwaukee, WI 53233, USA

¹BiodiversityOutreach Network, Flagstaff, AZ 86001, USA

Gil KKG.0000-0001-9445-0202;PG.0000-0002-7451-8369;FSV. 0000-0002-5270-5286

We analysed the wild bee community sampled from 1921 to 2018 at a nature preserve in southern Michigan, USA, to study long-term community shifts in a protected area. During an intensive survey in 1972 and 1973, Francis C. Evans detected 135 bee species. In the most recent intensive surveys conducted in 2017 and 2018, we recorded 90 species. Only 58 species were recorded in both sampling periods, indicating a significant shift in the bee community. We found that the bee community diversity, species richness and evenness were all lower in recent samples. Additionally, 64% of the more common species exhibited a more than 30% decline in relative abundance. Neural network analysis of species traits revealed that extirpation from the reserve was most likely for oligolectic ground-nesting bees and kleptoparasitic bees, whereas polylectic cavity-nesting bees were more likely to persist. Having longer phenological ranges also increased the chance of persistence in polylectic species. Further analysis suggests a climate response as bees in the contemporary sampling period had a more southerly overall distribution compared to the historic community. Results exhibit the utility of both long-term data and machine learning in disentangling complex indicators of bee population trajectories.

1. Introduction

Global reductions in pollinator populations are an increasingly documented threat to both food production [1] and terrestrial biodiversity [2]. These declines prompt interest in wild bee population trends to inform the science and practice of bee conservation [3]. Despite increased attention, trend analysis is frequently limited by short sample periods, offset sampling that does not cover whole flight periods and infrequent sampling. Additionally, due to inconsistent sampling per specific location, many studies of bee population trends have analysed datasets aggregated regionally or globally. These regional datasets are decidedly useful for examining trends in whole bee communities [4---6] or in specific insect groups (e.g. bumblebees [7,8]), but can introduce additional variability that complicates the detection of population changes.