Response to Messager *et al.* (2022)

In their paper entitled "Course-based undergraduate research to advance environmental education, science, and resource management", Messager *et al.* (2022) summarize the benefits and challenges of implementing ecological data collection within undergraduate courses and encourage leveraging such data collection to advance science, management, and policy. We applaud the authors' message, and particularly appreciate not only their broad perspective on how undergraduates can meaningfully contribute to science and management, but also their identification of zones of synergy between course-based undergraduate research experiences (CUREs) and citizen/community science. We would like to highlight other opportunities provided by several recently developed CURE networks that offer resources for collecting ecological data in undergraduate courses, efficiently assimilating and disseminating course data, and supporting instructors in these endeavors.

CURE networks – i.e., networks through which CURE data are collected and shared across multiple institutions – are increasingly accessible options for instructors to incorporate undergraduate research and collect ecological data within their courses (Connors *et al.* 2021). These networks are often already developed and themselves part of studies on effective scientific teaching (Bangera and Brownell 2014; Corwin *et al.* 2015; Buchanan and Fisher 2022; Patrick *et al.* 2023). As such, CURE networks can support, and lower barriers for, instructors looking to collect ecological data by providing training and teaching resources, data collection protocols and equipment, and centralized databases (Connors *et al.* 2021). Many of these resources and datasets arose or expanded during the COVID-19 pandemic (e.g., Dizney *et al.* 2020, 2021), resulting in a deliberate focus on flexible teaching modalities and equipment needs. Additionally, the pandemic may have catalyzed efforts to create and support networks to connect students and instructors, many of whom were suddenly working in isolation. Indeed, many conference themes (including at ESA) and funding opportunities have emphasized social connections. As a result, a number of networked CUREs – highlighted below – were developed or bolstered with easily adaptable and virtual resources to connect both instructor and student researchers across institutions, united in their pursuit of answers to authentic research questions.

Squirrel-Net (https://www.squirrel-net.org; Dizney *et al.* 2020) is one example of a CURE network that brings together students and institutions to create a community of researchers. Squirrel-Net offers four CURE modules focusing on different ecological aspects of squirrels, which are ubiquitous across many habitat types, including most college campuses in North America (Peplinski and Brown 2020). Each of the modules, which focus on behavior, giving-up density, population estimation techniques, or telemetry, has an associated shared database to which students add the data they collect. These large, shared databases enable the collection of ecological data at broad scales, thereby allowing students to generate hypotheses from a much broader range of questions than would be possible with data collected from just one institution.

Squirrel-Net is not the only example of a CURE network engaging students in data collection and research. Other ecology-focused CURE networks are unified by study organism, region, or topical approach. For instance, **SPARCnet** (Salamander Population and Adaptation Research Collaboration Network; http://sparcnet.org) coordinates course-based monitoring of salamanders, **RESCUE-Net** (rescue-net.org) explores ecological questions relevant to southern California, and the **SIRIUS Project** (Sustainable Interdisciplinary Research to Inspire Undergraduate Success Project; https://www.csus.edu/college/natural-sciences-mathematics/sirius; McDonald *et al.* 2019) focuses research on the ecosystem of California's American River. Research networks also vary in the degree to which they contribute to data collection and undergraduate research. For example, **BCEENET** (Biological Collections in Ecology and Evolution Network; https://bceenetwork.org) supports the development of CUREs in ecology and evolution using existing data from digitized natural-history collections. In contrast, **Snapshot USA** (https://emammal.si.edu/snapshot-usa; Cove *et al.* 2020) and **UWIN** (Urban Wildlife Information Network; https://www.urbanwildlifeinfo.org; Magle *et al.* 2019) were both initially organized to collect camera-trap data on wildlife across the US, but increasingly provide opportunities for students and volunteers to participate in ecological science. Similar to Squirrel-Net, several of these networks provide access to preexisting datasets and/or virtual participation options. The availability of these resources broadens the potential for *all* students to participate in authentic course-based research, regardless of their institutional resources, geographic location, or the specific habitats that are accessible from their home or campus.

In conclusion, we echo the sentiments of Messager *et al.* (2022) and also suggest that interested instructors consider networked CUREs and research collaborations as an option for bringing course-based research into the undergraduate classroom. These networks can catalyze student and instructor participation in authentic ecological research. The increasing availability of a variety of networked CUREs makes them a viable option for bringing research opportunities into a range of courses, from Introductory Biology to upper-division Ecology or Vertebrate Biology classes. By introducing real-world data collected by students across a broad geographic range into classrooms, educators can expand not only how our students interpret and understand ecological data, but also the degree to which those data may inform them about the world around us.

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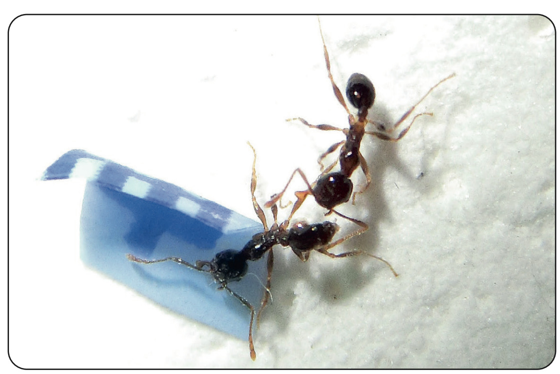
FrontiersEcoPics

Ants actively carry microplastics

Microplastics (<5 mm in diameter) are found in many regions of the world – from urban to relatively undeveloped areas, from the tropics to the arctic – and are recognized as a critical environmental issue. Certain biotic and abiotic factors (such as soil fauna and wind, respectively) may affect the distribution of microplastics in the environment. For example, it has been reported that earthworms (Lumbricidae) can incidentally ingest microplastics (*Sci Rep* 2017; doi.org/10.1038/s41598-017-01594-7), and springtails (Collembola) crawl over and push microplastics aimlessly in laboratory settings (*Environ Pollut* 2017; doi.org/10.1016/j.envpol.2017.03.009). However, we found that – unlike the accidental transport of microplastics by these fauna – ants (*Pheidole* sp; body length ~2 mm) were seemingly interested in microplastics, and actively carried them to their nests in both the field and lab.

Given the abundance and diversity of ants worldwide, ant-based transport of microplastics may be common in terrestrial ecosystems, which could further expand the distribution of these plastics and increase the probability that they enter groundwater. Questions that warrant further investigation include: Is this behavior associated with all, or only some, ant species? Why do ants carry microplastics into their nests? Do ants feed microplastics to their young? And do microplastics have a negative impact on ant populations?



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