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ARTICLE

Special Feature: Harnessing the NEON Data Revolution

Building communities of teaching practice and data-driven open education resources with NEON faculty mentoring networks

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Abstract

With the growing availability and accessibility of big data in ecology, we face an urgent need to train the next generation of scientists in data science practices and tools. One of the biggest barriers for implementing a data-driven curriculum in undergraduate classrooms is the lack of training and support for educators to develop their own skills and time to incorporate these principles into existing courses or develop new ones. Alongside the research goals of the NEON, providing education and training are key components for building a community of scientists and users equipped to utilize large-scale ecological and environmental data. To address this need, the NEON data education fellows program formed as a collaborative faculty mentoring network (FMN) between scientists from NEON and university faculty interested in using NEON data and resources in their ecology classrooms. Like other FMNs, this group has two main goals: (1) to provide tools, resources, and support for faculty interested in developing data-driven curriculum and (2) to make teaching materials that have been implemented and tested in the classroom available as open educational resources for other educators. We hosted this program using an open education and collaboration platform from the Quantitative Undergraduate Biology Education and Synthesis (QUBES) project. Here, we share lessons learned from facilitating five FMN cohorts and emphasize the successes, pitfalls, and opportunities for developing open education resources through community-driven collaborations.

KEYWORDS
data science, ecology education, FMN, macroscale data, OER, pedagogy, QUBESHub, Special Feature: Harnessing the NEON Data Revolution

INTRODUCTION

Working with authentic data increases student exposure to scientific practices and contributes to the development of quantitative skills (Farrell & Carey, 2018; Kastens et al., 2015; Kulasegaram & Rangachari, 2018; Langen et al., 2014). The successful integration of data-centric teaching practices plays a major role in efforts to transform ecology education, particularly in the light of rapidly growing and openly available "big data" in ecology (Michener &

Jones, 2012). Using openly available large datasets and computational tools in the classroom allows students to ask questions across multiple scales, whether temporal (e.g., seconds to decades), spatial (e.g., local to global), or ecological (e.g., micro to macro). While open access data and resources have dramatically increased, broad classroom integration of data-centric teaching approaches is more limited due to several barriers including time, training opportunities, and incentives. These challenges are particularly acute for the integration of large-scale ecological data, where the skills required to manipulate and analyze these datasets can be a large hurdle for both educators and students (Akman et al., 2020; Farrell et al., 2021). Data being collected by NEON is one such example of computationally intensive large-scale environmental data that can be intimidating for students and educators to bring into the classroom (Farrell & Carey, 2018; Langen et al., 2014). Here, we share the outcomes from a partnership between university faculty, NEON, and the Quantitative Undergraduate Biology Education and Synthesis (QUBES) project to provide educators access to open-source data, tools, and community support for bringing quantitative methods and NEON data into ecology courses.

The NEON project (neonscience.org) is funded by the National Science Foundation to generate a wealth of open-access environmental and organismal data that can be used for exploring a broad range of biological questions. Data collection occurs at 81 terrestrial and aquatic field sites in 20 ecoclimatic regions across the United States, and cleaning and quality checks are performed before being openly published on the NEON data portal. The accessibility and consistency of the datasets across NEON field sites make this resource ideal for use in ecology classrooms where students are also learning quantitative methods. Given the vast number of variables measured under consistent protocols, a wealth of authentic and investigative research questions is available for student exploration through guided inquiry or course-based research experiences. Data-based teaching resources are highly adaptable and can be used in a variety of teaching contexts, from online to lecture-based to quantitative laboratories, making these resources useful for a wide range of classrooms.

The QUBES project (QUBESHub.org), also funded by the National Science Foundation, is a cyberinfrastructure hub developed to bring math and biology educators together to create, share, and access data-driven open educational resources (OERs) for the global community of biology educators (Akman et al., 2020). In addition to an OER publishing platform, QUBES also provides a community space for educator professional development through in person workshops and virtual collaboration in faculty mentoring networks (FMNs) (Bonner et al., 2017; Donovan et al., 2015). In general, FMNs are peer support communities that provide tools, resources, and support for faculty interested in developing or implementing new approaches in the classroom. Using a basic template and virtual workspace provided to all FMN facilitators by QUBES, partner organizations customize the topic and goals of each group. Support staff from QUBES aid navigating the Hub features and guide facilitators in providing faculty professional development that includes advancing scholarly teaching practices. The NEON data education FMN discussed teaching topics to guide the design of classroom modules. After developing (or adapting) and successfully implementing the teaching module in the classroom, an end goal of all QUBES FMNs is publishing original and adapted teaching materials as OERs for use and further adaptation by other educators. Here, we share lessons learned from facilitating five FMN cohorts and emphasize the successes, pitfalls, and opportunities for developing OERs through community-driven collaborations.

NEON DATA EDUCATION FMN

The NEON data education FMN is a collaborative effort between NEON, QUBES, and college faculty with two main goals: (1) to provide tools, resources, and support for faculty interested in developing data-driven curriculum and (2) to make teaching materials that have been implemented and tested in the classroom available as OERs for other educators (Figure 1). In addition to the general FMN goals, the NEON data education FMN specifically focuses on creating awareness about NEON data and resources, and supports faculty in accessing datasets and tools for designing and implementing teaching materials in their classrooms. Participants are expected to attend 1-h biweekly virtual meetings for the semester (about 4 months) in a peer feedback group, create or adapt an OER using NEON data, and successfully implement that OER in their classrooms. Participants can work alone or in groups to develop an OER and submit their teaching materials for peer review. Peer feedback groups (4–8 faculty in each small group), a faculty facilitator, and a NEON scientist provide feedback on the educational module. Upon completion of the FMN including development, successful classroom implementation, and publicly sharing their OER through the QUBESHub or peer-reviewed journals, participants are recognized as NEON data education fellows. Publication of OER through the QUBESHub provides a digital object identifier for each submission that can be cited and contributes to a faculty member's teaching portfolio. Available teaching materials can be adapted through linked publications that attribute to the original resource.

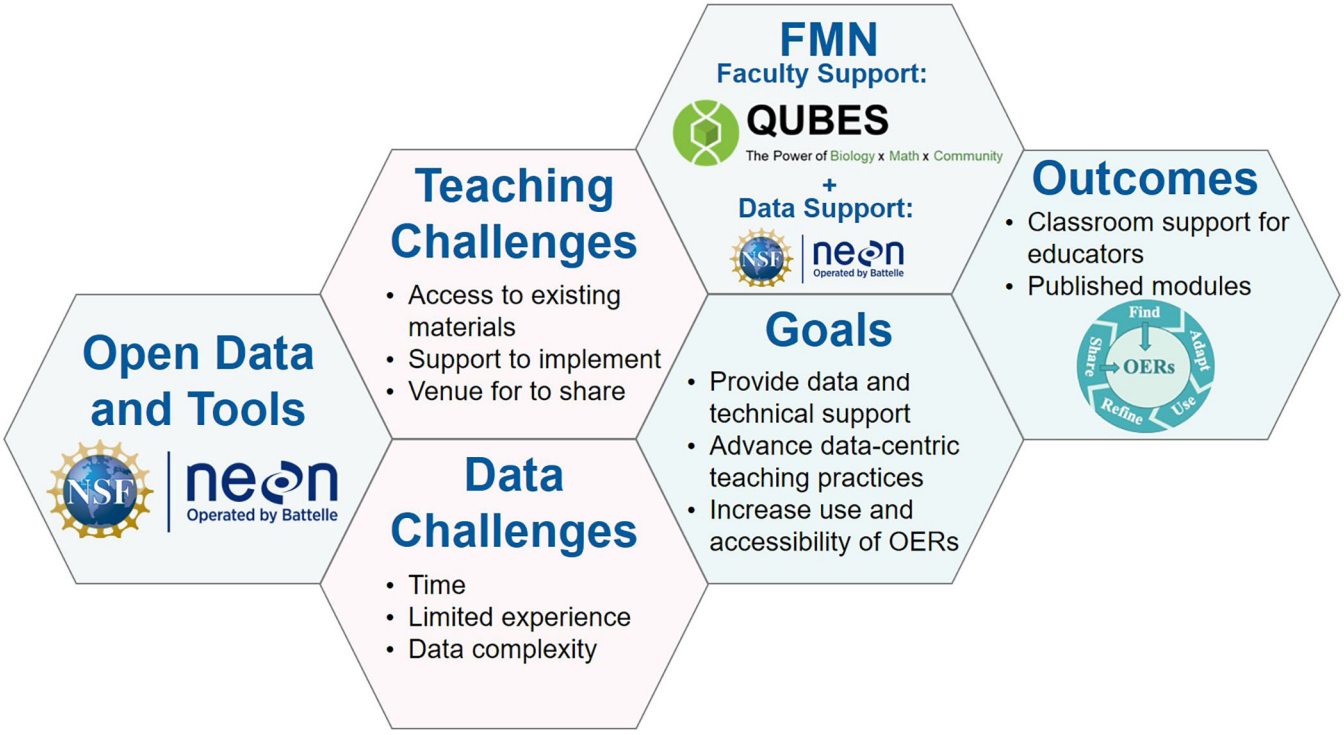

FIGURE 1 A conceptual framework of the NEON data education faculty mentoring network (FMN) in collaboration with the Quantitative Undergraduate Biology Education and Synthesis (QUBES) project. The NEON data education FMN is designed to meet the common teaching and technical challenges educators face for bringing large, authentic datasets into the classroom and to create high-quality, data-driven, open educational resources (OERs). Currently published OERs from the NEON data education FMNs are available here: https://qubeshub.org/community/groups/neon/educational_resources. The OER lifecycle diagram is adapted with permission from Jenny Kwan (QUBES).

Teaching materials developed by the FMN participants typically included datasets, student handouts and instructions, and a guide for faculty implementation. Students use the provided data, or access their own from the NEON data portal, to investigate an ecological data type and concept. For example, in the study by Bulluck (2019), students used bird survey data from the Great Smoky Mountains National Park site to compare bird diversity indices pre- and post-wildfire. In more inquiry-based modules, students are given a framework to develop their own questions and select appropriate NEON data to investigate their question. For example, in the study by Gough et al. (2018), students examined environmental drivers of carbon fluxes with either the instructor or the student specifying the parameters for a predictive model. More advanced students can be tasked with selecting the ecosystem, timescale, drivers of carbon flux process, and local environmental parameters to include in their model.

The NEON data education FMN cohorts began during the launch of the NEON data portal, where accessing data was not user friendly. Many of the current features and datasets became available as our FMN progressed, providing the opportunity to support educators navigating the portal for the first time and provide updates on new features. Educators with less expertise in Application Programming Interface and R gained experience using these tools, and in developing a teaching resource that matched the computational level of students in their class. The skills gained by faculty members to include NEON data in their teaching provides additional benefits through the opportunity to incorporate these data into their future research and build connections and relationships with NEON scientists.

While advancing student training in quantitative skills, educators also gained experience in best practices for inclusive teaching through discussions of published literature, occasional guest lectures from pedagogical experts, and sharing their own classroom experience with each other. These topics included data-driven pedagogy (e.g., Kastens et al., 2015; Langen et al., 2014), universal design of learning and instruction (e.g., Burgstahler, 2009; Simón et al., 2021), backward design (e.g., Michael & Libarkin, 2016), student assessment (e.g., Kulasegaram & Rangachari, 2018; Tanner & Allen, 2004), and OERs (e.g., Armellini & Nie, 2013; Farrow, 2017; Ferguson, 2017).

The benefits to students include building quantitative skills, awareness of environmental sensor networks, and participation in inquiry-based investigations with large datasets. Training received by students from classroom exposure to NEON teaching resources contributes to

national priorities for increasing student interest in macroscale research questions and ecological career opportunities (Farrell et al., 2021). The wider ecological community benefits from NEON FMNs as data-driven teaching materials that have been implemented and tested in classrooms are openly available. These resources are part of a growing collection of educational tools to bring large environmental datasets and macroscale ecological principles to the classroom (see also EDDIE and Macrosystems EDDIE; Farrell & Carey, 2018; O'Reilly et al., 2017).

SUCCESSES AND PITFALLS

The NEON data education FMN has been offered for five semester-long cohorts (spring 2018–spring 2020, eight FMN peer feedback groups) with 53 faculty participating, resulting in a wide variety of new and adapted data-driven teaching modules. All NEON data education FMN participants were asked to complete pre- and post-FMN surveys to assess the effectiveness of the FMN (survey questions are available in Appendix S1: Tables S1 and S2). The FMN participants are associated with a variety of institutions across North America (Figure 2) including research universities, primarily undergraduate institutions, and community colleges, but the majority (68%) of the participants came from research universities (Figure 3). The majority (73.6%) of FMN participants were early career faculty (≤6 years in their current

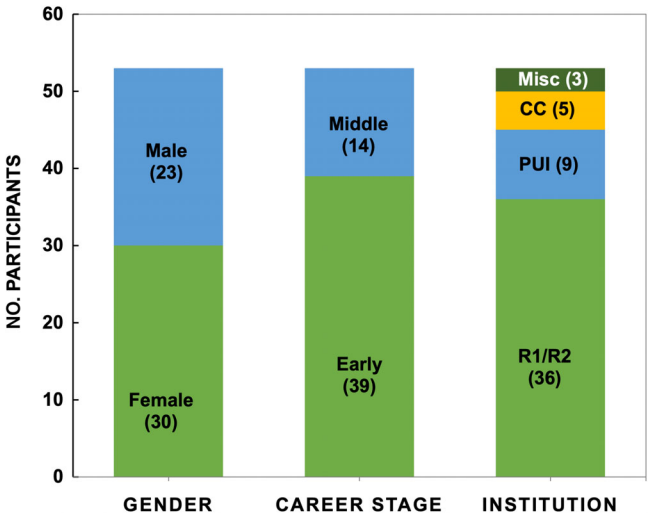

FIGURE 3 Description of the NEON data education faculty mentoring network participants based on their gender (male and female, none undeclared gender), career stage (early ≤6 years and middle 6–10 years), and institution type (research universities [R1/R2], primarily undergraduate institutions [PUI], community colleges [CC], and miscellaneous [Misc; includes government agency and research institutions]).

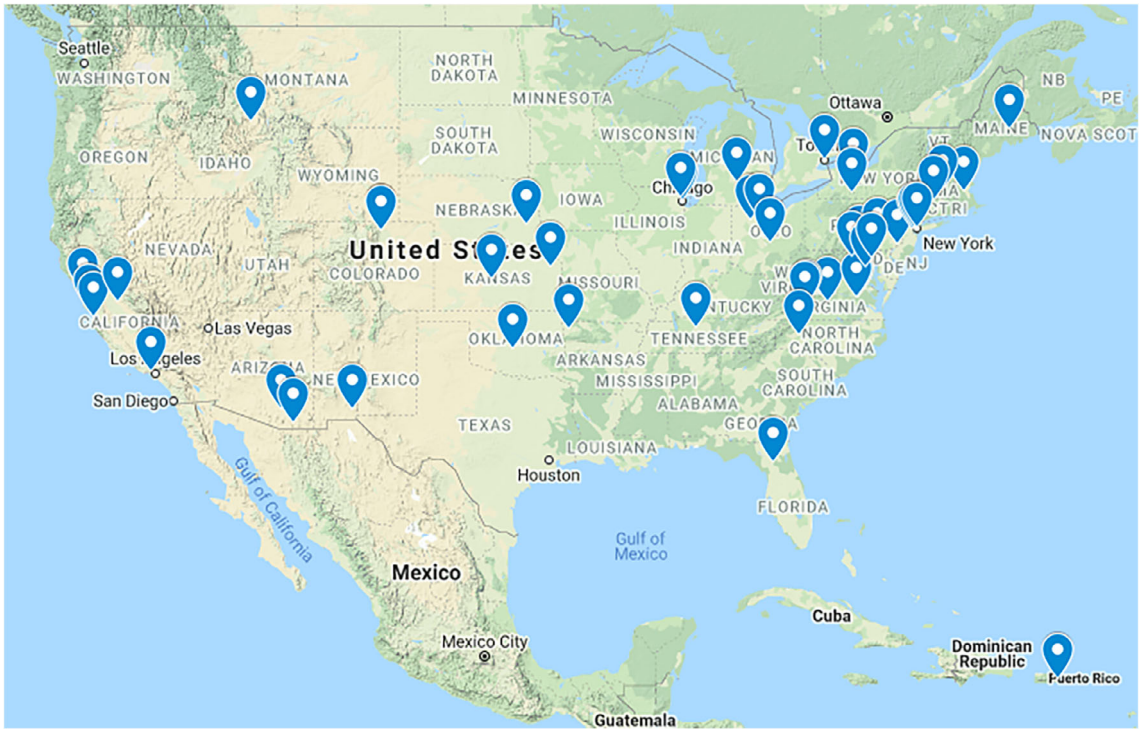

FIGURE 2 Map (made using Google Maps) showing the institutional locations of the NEON data education faculty mentoring network participants across North America.

position) and female faculty participation (56.6%) was higher than male faculty (Figure 3).

In the post-FMN survey, respondents said they will be comfortable in accessing NEON data (60% "Definitely" and 40% "Probably") and will continue using NEON data (70% "Definitely" and 30% "Probably") for their future teaching and research (Figure 4). All respondents (92% "Strongly agree" and 8% "Somewhat agree") agree that participating in the NEON data education FMN increased their knowledge of OER teaching resources (Figure 5). While all the participants developed and implemented an OER using NEON data in their classroom, only 19 participants published (15 OERs) their material publicly on QUBESHub (available here: https://qubeshub.org/community/groups/neon/educational_resources). These modules range in topic from data management to ecological concepts focused on population to landscape ecology (Table 1). While most of these resources are developed for classroom implementation with R statistical software (R Development Core Team, 2020), some resources use Excel for accessibility to students earlier in their quantitative skills development (Table 1).

We encouraged participants to share their teaching materials via QUBESHub to allow opportunities for receiving feedback from the community and recognize the value of community efforts that can continue the process of adaptation and improving teaching resources, as opposed to the individual effort in conventional refinement of course materials and pedagogical approaches. Due to the low number of published OERs in comparison to the number of participants, we added additional incentives in later years including NEON data education FMN fellow status and a certificate that can be used in participant's teaching portfolio (see here: https://www.neonscience.org/resources/learning-hub/data-education-fellows), but several participants expressed "lack of time" and "lack of recognition from their home institution in promotion and tenure" (personal communication) as the primary reasons for not posting the final materials. Pandemic disruptions also interrupted the progress of the final cohort in spring 2020.

Our interactions with educators during the FMNs highlighted the conflict that educators felt with how much they should assist students in accessing and cleaning the data and the time constraints present in existing courses for teaching computational skills (issues raised during biweekly discussions, no data available). Providing pre-downloaded and cleaned data allows educators to use data as a case study to reinforce ecological concepts, while guiding students through the downloading and data cleaning allows educators to emphasize on the complexity and messiness of real-life data.

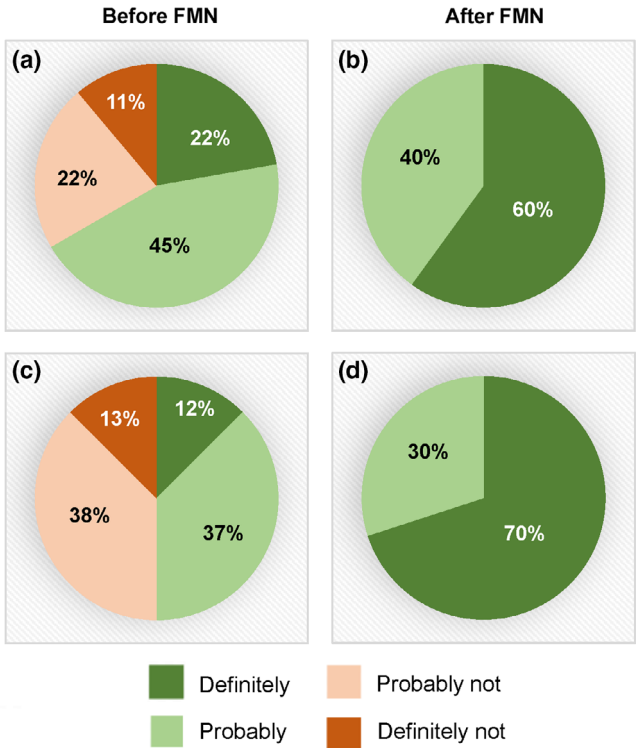

FIGURE 4 Pre- and post-survey results showing participants' comfort accessing NEON data (a and b) and likelihood of using NEON data in their future teaching and research (c and d) before and after participating in the NEON data education faculty mentoring network (FMN). $N = 10$ for two cohorts of participants in 2018. These questions were removed from future surveys as Quantitative Undergraduate Biology Education and Synthesis standardized survey questions across all FMNs.

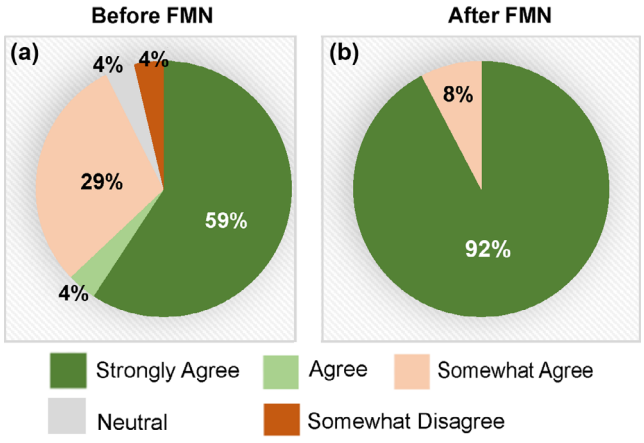

FIGURE 5 Pre- and postsurvey results showing participants' knowledge of open educational resource teaching resources (a) before, and (b) after participating in the NEON data education faculty mentoring network (FMN). $N = 26$ for five cohorts of FMN participants.

TABLE 1 Description of published open educational resources (OER) developed with the support of NEON data education faculty mentoring networks.

Author, year	Topic	Type of OER	Data; software	DOI; views; downloads
Spera (2020)	Environmental studies	Original	Tick count; Excel	10.25334/1XYA-TF48; 964; 641
Naithani (2020)	Landscape ecology	Original	LIDAR; R	10.25334/AJBF-AZ49; 962; 278
Xie (2020)	Data science	Original	Airborne; R	10.25334/CPFG-B331; 864; 432
Bulluck (2019)	Environmental studies	Original	Bird survey; R	10.25334/R2S1-4S62; 28,711; 789
Aiello-Lammens (2020)	Data science	Original	Plant presence and % cover; R	Published on GitHub
Hernández-Pacheco (2018)	Ecology	Adaptation	Small mammal; Excel	10.25334/Q44X4D; 1497; 619
Campany and Kang (2019)	Disease ecology	Original	Mosquito survey, climate; Excel, R	10.25334/25CW-6988; 654; 650
Whitney (2019)	Environmental workshop	Original	Aquatic macro-invertebrate abundance; Excel	10.25334/SJX1-F373; 1312; 343
Santangelo (2019)	Ecology	Original	Plant presence/absence; R	10.25334/Q4CT7P; 796; 555
Bonsma-Fisher and Hasan (2018)	Ecology	Original	Plant Phenology; R	10.25334/Q4Q73D; 1318; 953
Jones (2018)	Ecology	Adaptation	Climate; Excel	10.25334/Q4F43W; 1166; 1043
Matthes (2018)	Ecology	Original	Plant Phenology; R, Shiny App	10.25334/Q4HQ54; 1600; 609
Gough et al. (2018)	Ecosystem ecology	Original	Eddy Covariance; R	10.25334/Q4VD7W; 2305; 903
Cowden (2018)	Introduction to R	Adaptation	Plant phenology and air temperature; R	10.25334/Q4QX4P; 1583; 637
Swetnam and Jones (2018)	Introduction to CyVerse	Original	LIDAR; R	10.25334/Q48T4M; 1190; 445

Since May 2018, the published NEON FMN OERs have been collectively viewed 44,922 times and downloaded 8897 times (as of 25 November 2021; Table 1). We found the QUBES-FMN model to be successful in providing online professional development and creating communities of educators without geographic barriers. Our work highlights how this model of curriculum development and faculty engagement can be successfully applied in bringing publicly available and large datasets in ecology classrooms.

LESSONS LEARNED AND OPPORTUNITIES FOR FUTURE

Participants in the NEON data education FMNs represent a group of educators with a wide variety of data science expertise and a strong interest in using openly available data and tools in undergraduate and graduate classrooms. We used the conceptual framework of FMN and open data and tools from NEON to facilitate the development and use of OERs in undergraduate and graduate classrooms. The developed teaching resources span a range of software tools and data complexity. Regardless of the topic or analysis approach, all educators felt that they needed time and training to develop or adapt new teaching materials and build data science skills to better incorporate the data revolution in ecology into the classroom. Opportunities for specialized support for tackling large ecological datasets in the classroom may be limited from individual institutions (Farrell et al., 2021), and the FMN model addresses these gaps in instructor preparation by providing field-specific training and professional development. Most participants felt that the FMN and community-driven approach to developing OERs promotes the inclusion of openly available large-scale data and tools in ecology classrooms, fosters student learning, reduces time commitment from individual faculty, and creates a supportive environment for faculty to develop new skills. Future opportunities should consider how to expand the support and training of teaching faculty, both in building additional resources and supporting faculty to use them.

Further work is needed to fully understand the barriers experienced by FMN participants for final

publishing of OER materials and could aid in designing additional support or incentives to improve participation. Future FMN networks could explicitly assess publication barriers and include additional follow-up with participants. Recognition from institutions in tenure and promotion considerations could certainly increase the motivation of participants to publicly share educational materials. The high number of views and downloads of resources from the NEON data education FMNs emphasizes the value and desirability of these materials for the broader ecology education community. As the value and use of OER in the classroom continues to expand, the benefits and recognition for participants can also increase and further support the growing community for improving resources and pedagogy in ecology education.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Data (Naithani et al., 2022) are available from Dryad: https://doi.org/10.5061/dryad.f1vhhmh03.

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REFERENCES

Aiello-Lammens, M. E. 2020. "NEON-on-Mobile." https://mlammens.github.io/NEONonMobile/.

Akman, O., C. D. Eaton, D. Hrozencik, K. P. Jenkins, and K. V. Thompson. 2020. "Building Community-Based Approaches to Systemic Reform in Mathematical Biology Education." *Bulletin of Mathematical Biology* 82: 109.

Armellini, A., and M. Nie. 2013. "Open Educational Practices for Curriculum Enhancement." *Open Learning: The Journal of Open, Distance and e-Learning* 28: 7–20.

Bonner, K. M., A. E. Fleming-Davies, K. L. Grayson, A. N. Hale, X. B. Wu, and S. Donovan. 2017. "Bringing Research Data to the Ecology Classroom through a QUBES Faculty Mentoring Network." *Teaching Issues and Experiments in Ecology* Vol. 13. Commentary [online].

Bonsma-Fisher, M., and A. Hasan. 2018. "Working with Plant Phenology Data and Fitting a Nonlinear Model using Least Squares in R." http://dx.doi.org/10.25334/Q4Q73D.

Bulluck, L. 2019. "Testing Hypotheses about the Role of Wildfire in Structuring Avian Communities. NEON Faculty Mentoring Network (Version 2.0)." QUBES Educational Resources. https://doi.org/10.25334/R2S1-4S62.

Burgstahler, S. 2009. *Universal Design of Instruction (UDI): Definition, Principles, Guidelines, and Examples*. Seattle, WA: DO-IT, University of Washington.

Campany, C., and D. Kang. 2019. "Mosquito Vector Ecology of the East Coast using NEON." http://dx.doi.org/10.25334/25CW-6988.

Cowden, N. 2018. "Gaining Familiarity with R and Work with NEON OS & IS data – Plant phenology & temperature - adaptation." https://qubeshub.org/publications/624.

Donovan, S., C. D. Eaton, S. T. Gower, K. P. Jenkins, M. D. LaMar, D. Poli, R. Sheehy, and J. M. Wojdak. 2015. "QUBES: A Community Focused on Supporting Teaching and Learning in Quantitative Biology." *Letters in Biomathematics* 2: 46–55.

Farrell, K. J., and C. C. Carey. 2018. "Power, Pitfalls, and Potential for Integrating Computational Literacy into Undergraduate Ecology Courses." *Ecology and Evolution* 8: 7744–51.

Farrell, K. J., K. C. Weathers, S. H. Sparks, J. A. Brentrup, C. C. Carey, M. C. Dietze, J. R. Foster, K. L. Grayson, J. H. Matthes, and M. D. SanClements. 2021. "Training Macrosystems Scientists Requires Both Interpersonal and Technical Skills." *Frontiers in Ecology and the Environment* 19: 39–46.

Farrow, R. 2017. "Open Education and Critical Pedagogy." *Learning, Media and Technology* 42: 130–46.

Ferguson, C. L. 2017. "Open Educational Resources and Institutional Repositories." *Serials Review* 43: 34–8.

Gough, C. M., Giffen, C., Woodward, T. W. 2018. "Environmental Drivers of Ecosystem Carbon Fluxes from Minutes to Years." NEON Faculty Mentoring Network, QUBES Educational Resources. https://doi.org/10.25334/Q4VD7W.

Hernández-Pacheco, R. 2018. "More In Depth Spreadsheet Management Adaptation of Data Management using NEON Small Mammal Data." http://dx.doi.org/10.25334/Q44X4D.

Jones, A. C. 2018. "NEON Data in the Classroom: Implementing and Adapting an Open Education NEON Resource "Quantifying the Drivers and Impacts of Natural Disturbance Events-The 2013 Colorado Floods" for the Southern California Classroom." http://dx.doi.org/10.25334/Q4F43W.

Kastens, K., R. Krumhansl, and I. Baker. 2015. Thinking Big: Transitioning Your Students from Working with Small, Student-Collected Data Sets Toward 'Big Data.' *The Science Teacher* 82: 25–31.

Kulasegaram, K., and P. K. Rangachari. 2018. "Beyond 'Formative': Assessments to Enrich Student Learning." *Advances in Physiology Education* 42: 5–14.

Langen, T. A., T. Mourad, B. W. Grant, W. K. Gram, B. J. Abraham, D. S. Fernandez, M. Carroll, et al. 2014. "Using Large Public

Datasets in the Undergraduate Ecology Classroom." *Frontiers in Ecology and the Environment* 12: 362–3.

Matthes, J. 2018. "Outstanding Oaks: Quercus Phenology at NEON Sites." http://dx.doi.org/10.25334/Q4HQ54.

Michael, N. A., and J. C. Libarkin. 2016. "Understanding by Design: Mentored Implementation of Backward Design Methodology at the University Level." *Bioscene: Journal of College Biology Teaching* 42: 44–52.

Michener, W. K., and M. B. Jones. 2012. "Ecoinformatics: Supporting Ecology as a Data-Intensive Science." *Trends in Ecology & Evolution* 27: 85–93.

Naithani, K. 2020. "NEON Data in the Classroom: Quantifying Spatial Patterns." http://dx.doi.org/10.25334/AJBF-AZ49.

Naithani, K., M. Jones, and K. Grayson. 2022. "Data from: Building Communities of Teaching Practice and Data-Driven Open Education Resources with NEON Faculty Mentoring Networks." Dryad. Dataset. https://doi.org/10.5061/dryad.f1vhhmh03.

O'Reilly, C. M., R. D. Gougis, J. L. Klug, C. C. Carey, D. C. Richardson, N. E. Bader, D. C. Soule, et al. 2017. "Using Large Data Sets for Open-Ended Inquiry in Undergraduate Science Classrooms." *Bioscience* 67: 1052–61.

R Development Core Team. 2020. *R: A Language and Environment for Statistical Computing*. Vienna: R Foundation for Statistical Computing.

Santangelo, J. S. 2019. "Data simulation and randomization tests." http://dx.doi.org/10.25334/Q4CT7P.

Simón, C., Y. Muñoz-Martínez, and G. L. Porter. 2021. "Classroom Instruction and Practices that Reach all Learners." *Cambridge Journal of Education* 51: 607–25.

Spera, S. 2020. "Intro to Data Types and Graphing Lab." http://dx.doi.org/10.25334/1XYA-TF48.

Swetnam, T. L., and M. A. Jones. 2018. "CyVerse Tutorials for NEON Data Science Institute 2018." http://dx.doi.org/10.25334/Q48T4M.

Tanner, K., and D. Allen. 2004. "Approaches to Biology Teaching and Learning: From Assays to Assessments—On Collecting Evidence in Science Teaching." *Cell Biology Education* 3: 69–74.

Whitney, K. S. 2019. "Introduction to Data Management and Metadata using NEON aquatic macroinvertebrate data." http://dx.doi.org/10.25334/SJX1-F373.

Xie, Y. 2020. "Remote sensing data processing - NEON airborne data." http://dx.doi.org/10.25334/CPFG-B331.

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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