NEON scientist: a new career choice in ecology

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It's 8:30 am and a touch chilly at –32°C and I'm standing around at the Caribou-Poker Creeks Research Watershed site in central Alaska. I'm waiting while the space heater that's set up under a makeshift tent and plugged into the generator I slept with in my hotel room (to keep it warm enough to start here in the field) – is blowing hot air on the engine block of our drilling rig, so it too will start. This is what it takes to meet construction schedules, complete drilling holes for NEON soil temperature and moisture sensors, and supply the NEON Soil Archive with samples, which my colleagues and yours can request for their research. In my view this is the most exciting part of being a network scientist – not standing around freezing per se, but rather contributing to a national platform that will support scientific advancements in ecology over the next three decades. For me, it's the highly collaborative and altruistic nature of NEON that makes it most appealing. – *MSC*

"Slugs and slug slime? Why do I, as a small mammal ecologist, have to worry about slugs?", I say to the patient Harvard Forest researcher who is helping me and the NEON field staff implement the NEON small mammal protocol (I had written) for the first time at the Harvard Forest LTER/NEON site. In the decade or so of field experience trapping small mammals in the Southwestern US I had under my belt at that point, I never (ever!) had to deal with slugs filling the traps and covering them with their slime. This is one of many things I have learned as a NEON scientist attempting to devise a clear and comprehensive field sampling protocol that can be applied across an incredible diversity of ecosystems. Helping to design and implement a standardized network of sampling has been one of the most challenging and rewarding aspects of my career. Each site presents new obstacles to overcome in order to fulfill NEON's mission to transform our ability to understand ecological dynamics across spatial and temporal scales. – *KMT*

In today's scientific landscape there are numerous invaluable networks; examples include the Long Term Ecological Research (LTER) Network, the AmeriFlux Network, the National Ecological Observatory Network (NEON), the National Critical Zone Observatory Program, and the Long-Term Agroecosystem Research Network. These networks are critical to furthering our understanding of mechanistic site-based ecological principles, monitoring fluxes across the landscape, interpreting interactions between environmental change and agricultural practices, and more. Countless opportunities exist for scientists to interact with networks or even to have a fully network-based career in the unique case of NEON.

Preparing oneself for a career in network science at NEON can proceed along many paths, depending on one's background, interests, and future aspirations. With 81 field sites (47 terrestrial and 34 aquatic), 177 freely available data products, and infrastructure designed for community collaboration, just about every skill set imaginable is needed to keep NEON operating on a day-to-day basis. The incredible variability required to make NEON function means that a career in NEON science can be a great fit for just about anyone. Love coding, QA/QC, and statistics? – you can focus on that. Field work? – yep. Communications and outreach? – that's a big part. Science management? – we've got that too. Plus, NEON's data span a wide range of disciplines from biogeochemistry to vertebrate ecology, providing scientists from numerous fields the chance to continue along a career path in their primary discipline within the framework of the observatory.

For aspiring scientists, a position as one of our more than 200 seasonal field ecologists is not only an excellent summer employment opportunity but also the equivalent of an intensive course in field ecology methods. Temporary field staff are typically undergraduate students enrolled in programs related to ecology and the environmental sciences. Because these positions are distributed across the entire country, there's a good chance that such a position will work for you, regardless of where you live. Seasonal field staff jobs focus on a number of different NEON subsystems such as deploying and maintaining aquatic or terrestrial instrumentation, collecting grab samples for aquatic or terrestrial biogeochemistry, and even trapping and tagging adorable small mammals (Figure 1). Chances are you will gain invaluable experience in your primary field of study and several new ones too.

NEON also employs dozens of permanent scientists across the regional facilities distributed throughout the observatory and at its headquarters in Boulder, Colorado. Scientists working out of the regional labs are responsible for managing and implementing all of the site-based activities, including the recruiting, training, and directing of the annual cohort of seasonal technicians needed to conduct the 40+ observational sampling protocols and maintain the sensors and infrastructure. Permanent field science staff generally have undergraduate or MS degrees in ecology or broadly related fields. The field

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operations scientists also conduct regional educational and outreach activities. Scientists working out of NEON HQ are responsible for contributing to the design and implementation of observatory science as well as the dissemination of the publicly available data and infrastructure that are central to our mandate. This includes everything from deciding the initial placement of sensors and field plots; to writing, evaluating, and selecting protocols for field sampling and sensor maintenance; coding algorithms that generate final data streams; and even configuring the architecture of the data portal itself. NEON HQ scientists typically have master's degrees and/or PhDs in ecology or Earth science with expertise in one or more of NEON's scientific themes and/or automated data QA/QC and analytics routines.

Unique to NEON within the field of ecology is its highly centralized infrastructure, management, and data services. This means that, despite NEON's dispersed footprint and 81 sites from Puerto Rico to Alaska, all scientific designs and priorities flow from its headquarters in Boulder, while all data flow back for processing and posting to our portal. Once posted it is freely available for download by anyone. NEON relies on this structure to help facilitate the generation of scalable and interoperable data targeted at answering a new generation of scientific questions related to macrosystems biology (ie biological, geophysical, and social components from regional to continental scales). Building and operating NEON necessitates not just ecologists and Earth scientists, but engineers, cyber infrastructure specialists, project managers, regional managers, communications staff, and more. Scientists regularly participate in and lead interdepartmental working groups within the organization, requiring a highly team-oriented personality and a willingness to incorporate multiple perspectives into planning and decision making.

NEON also has an outwardly collaborative nature. NEON scientists have drawn on the expertise of the greater scientific community throughout the design and initial implementation of NEON science, through both informal discussion and formal working groups. NEON scientists regularly liaise with members of the external science community by attending academic conferences to provide updates on NEON developments, host workshops, and increase awareness of NEON data. Collaborations with their external counterparts extend into the day-to-day routine of NEON scientists and staff as well. Our mission as providers of open-source data and shared infrastructure requires frequent interactions with users as we assist them in navigating our science designs and protocols, conducting complementary research at NEON sites, accessing and interpreting the data, and collaborating on research proposals and manuscripts.

Whether your end goal is to test the waters for a career in network science or use NEON resources to supplement your research at another institution, entry points into the NEON user community abound. NEON provides an ever-expanding suite of tutorials, informational videos, workshops, and data science courses aimed at increasing the dissemination and efficacy of the observatory as a platform for transformative science over the next 30 years. The NEON website (www.neonscience.org) is a great resource that can point you to information about accessing NEON data, infrastructure, and job openings. To keep up with the latest developments and opportunities, follow NEON on the various social media platforms. Finally, NEON advertises job openings on Society mailing lists like ECOLOG-L (recently rebranded as ESA's ECO platform).

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Figure 1. NEON field scientists Madeline Pike and Frank Schroyer conduct small mammal sampling at the NEON site at Konza Prairie Biological Station in northeastern Kansas.

The potential to transform the field of ecology – combined with a large number of existing collaborators and an ever-growing number of supported users – makes the career path of a NEON scientist highly rewarding.

Author biographies

Michael D SanClements is the Lead of Terrestrial Instrument Science at NEON and Chair Elect of the Soil Science Society of America's Division of Forest, Range, and Wildland Soils. He is also the author of the book *Plastic Purge* from St Martin's Press.

Katherine M Thibault is the NEON Science Lead and manages the science components of the NEON project, providing budgetary and technical oversight. She joined NEON in 2011 to design the mammal and bird sampling protocols. She earned her PhD at the University of New Mexico, investigating rodent community dynamics, and conducted her postdoctoral work in macroecology at Utah State University.

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