24 Confessions of a Fungal Systematist

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IN A NUTSHELL

1. The Long-Term Ecological Research (LTER) program has not influenced my basic approach to science.
2. The LTER program has reinforced my approach to mentoring, and it has increased my opportunities to mentor students through the LTER-associated Research Experiences for Undergraduates Program.
3. LTER program has greatly enriched my collaborative network and expanded my research in directions that I would not have otherwise pursued; similarly, I have expanded the research and perspectives of my collaborators.
4. My involvement in the LTER program has changed my perspective in reviewing grant proposals and manuscripts.

PERSONAL OVERVIEW

I have been a co-principal investigator or senior personnel at the Luquillo site (LUQ) of the LTER since its inception in 1988. My MS was on fungal population genetics and epidemiology of a plant pathogen, and my PhD work involved a study of the ecology of arbuscular and ectomycorrhizal fungi associated with cottonwood and willow, with a minor in entomology. I was employed as an ecosystem ecologist for the first 9 years of my professional career as a research scientist with the University of Puerto Rico, Center for Energy and Environment Research, which later became the Terrestrial Ecology Division. My early research in the LTER program focused on the role of arbuscular mycorrhizal fungi in plant colonization of landslides in collaboration with plant ecologists and physiologists in the "disturbed plant group." Hurricane Gilbert struck Jamaica in 1988, shortly after I had measured vegetation there, so I returned to Jamaica with a group that was studying migrant bird habitat and helped to remeasure plants. I used this opportunity to design the tree damage protocol that was used in 1989, when Hurricane Hugo struck the Luquillo Experimental Forest in Puerto Rico (the location of LUQ) (Zimmerman et al. 1994). Consequently, I was nicknamed "Hurricane Hattie" by my collaborators at the Coweeta LTER site.

Throughout my career, I have used my graduate training in ecology and soil microbial ecology to make important estimates of fungal and bacterial biomass and nutrient immobilization, and to determine what factors control spatial and temporal patterns in fungal distributions, abundance, and diversity (Lodge and Cantrell 1995; Lodge 1997). I received additional training to run a radioactive phosphorus tracer experiment to show fungal translocation of phosphorus by leaf decomposer fungi in microcosms at the Institute for Terrestrial Ecosystem Studies in England.

After arriving in Puerto Rico in 1982, I began describing new species of fungi with additional training in taxonomy and systematics at the Field Museum of Natural History in Chicago and the Royal Botanical Garden, Kew, in England. I took a position in tropical fungal systematics with the Center for Forest Mycology Research in the US Forest Service in 1992, which is when the main focus of my research changed to fungal classification. Many years ago, at the second LTER All Scientists Meeting, more than 30 LTER researchers who considered themselves to be taxonomists or systematists gathered in a circle after lunch and introduced themselves. As one of the first, I introduced myself as a fungal systematist masquerading as an ecosystem ecologist. Subsequently, everyone else in the circle confessed to being a "closeted" systematist or taxonomist, as if it were a gathering of "systematists anonymous." Based on my experiences and of others in the group, it appears that the "big tent" approach to ecology at most LTER sites has provided a niche where systematists and taxonomists can survive in a research climate that has generally lost sight of the importance of species.

APPROACH TO SCIENCE

If I had not been involved with LUQ, I probably would not have become involved in one of my main ecological research foci: the roles of mushrooms in leaf litter decomposition, nutrient cycling, and erosion control (Lodge et al. 2008). I am probably better known now as an ecologist than I am as a systematist, largely as a consequence of my research in the LTER program. I, and most other systematists in the LTER program, am concentrated in disciplines with highly diverse groups such as fungi and invertebrates, and these organisms play critical roles that influence ecosystem processes such as herbivory, plant survivorship, seed dispersal and pathology, decomposition, and nutrient cycling. My work and that of other taxonomists and systematists in the LTER program largely

focus on the effects of keystone or dominant species and functional groups. The groups of organisms we work with, such as decomposers, have often been treated as belonging to "black box" compartments in ecosystem processes. Our research shows, however, that the species or functional groups inside the black boxes influence rates of ecosystem processes and the fate of carbon and nutrients. For example, we showed that the species of microfungi that are dominant early decomposers of particular leaf species decompose their preferred hosts faster than do dominants from other leaf species (Santana, Lodge, and Lebow 2005). Also, we showed that the presence of a different functional group of decomposers (mushrooms that degrade lignin) greatly accelerated decomposition beyond that caused by microfungi (Santana, Lodge, and Lebow 2005; Lodge et al. 2008). In addition, we confirmed that lignin-degrading mushrooms were inhibited by nitrogen loading (Lodge et al. 2008) and canopy opening from hurricane wind damage (Lodge and Cantrell 1995). Predicting responses to disturbance, nitrogen loading, or climate change can be difficult without knowledge of the species or functional groups that mediate ecosystem processes and how they respond to stress.

Like many of the taxonomists and systematists in the LTER program, I was cross-trained in ecology. I sought ecology training in graduate school, partly because there were (and still are) more positions available in research and academia for ecologists than there are for systematists. The cross-disciplinary training that many taxonomists and systematists received is preadaptive to the interdisciplinary research in the LTER program. Not only does ecological training allow systematists and ecologists to occupy niches in research in the LTER program, but it also hones skills in explaining ideas and principles to those from different disciplines.

ATTITUDES TOWARD TIME AND SPACE

My research has always been oriented toward changes in time and space, and that has not changed with my involvement with the LTER program. Although I have a greater appreciation of socioecological interactions through my involvement, I have not yet incorporated it into my research program.

COLLABORATION

If I had not been involved in the LTER program, I would not have become involved in collaborative research on primary succession in landslides, secondary succession following hurricanes, or the effects of hurricanes on vegetation composition and structure (Zimmerman et al. 1994), nutrient immobilization, and litter deposition and decomposition (Lodge et al. 2008). Similarly, I doubt that most of my coauthors in the "disturbed plant group," who were stream chemists and forest ecologists, would have become involved in the autecology of basidiomycete leaf decomposers or their roles in nutrient cycling and erosion control (Lodge et al. 2008). Although I can easily say that my involvement in research at LUQ has led me to be more multidisciplinary, collaborative, synthetic, and insightful in my research, I cannot say that my research is more theoretical or comparative because of that involvement.

One of the downsides of my early involvement in the LTER program was having been "plugged into" gaps in research proposals because I had useful skills rather than the desire to carry out those particular aspects of research. Although research on arbuscular mycorrhizae is important and intellectually challenging, I had no desire to continue mycorrhizal research after having examined a mind-numbing number of samples under the microscope for my doctoral dissertation. Instead, I trained graduate students interested in that

type of research. I have learned to be more selective and to say "no" much more to invitations for collaborative research, so that I have enough time to pursue my main interests and what I consider to be important. My main criteria for saying "yes" to a collaborative research request is whether it intrigues me, and whether it is what I do best. I say "no" when others could better take on a particular aspect or when it is mind-numbing.

APPLIED RESEARCH

Although I appreciate applied aspects of research, I cannot say that my experience in the LTER program has altered my views. Although some of my research publications from the LTER program are in part or mostly applied (e.g., Miller and Lodge 2007; Lundquist et al. 2011), I have always had dual basic and applied aspects in my research and student training. My research and publications from the LTER program have fostered collaborations with foresters and forest pathologists (e.g., Lundquist et al. 2011) as well as with national forest ecosystem managers.

COMMUNICATION

As a full-time government researcher, I do not regularly teach classes, although I do train graduate students and give guest lectures and workshops. Most of my teaching is through outreach or mentoring activities.

MENTORING

LUQ has a strong Research Experiences for Undergraduate (REU) program that has provided valuable training for undergraduate students and mentoring opportunities for me. In addition, I have also mentored high school students in their science fair projects. The REU students are trained by a dedicated staff person in designing research, statistical analysis, and presentation; they are part of a social cohort; and I encourage them to help each other with their projects. The REU application process is very competitive, and I can select highly motivated students with interest in areas of research similar to mine. Based on my experiences in collaborative research in the LTER program, I am careful to not push students into projects. Once a student is selected, I like to see what topic lights up their imagination and engages their thought processes. Otherwise, the LTER program has not influenced the way that I mentor students or junior faculty members; rather, it has provided me with more opportunities and an ideal environment in which to do so.

My research experiences in the LTER have altered how I evaluate research proposals and manuscripts. I am now quick to look for underpinning paradigms that are being proposed or tested and whether the proposed research or results are able to support or refute the paradigms. Also, I place more value on proposals that can leverage data by being colocated or coordinated with other studies. In addition, I look for the applicability of the results to solving problems and understanding responses in complex ecosystem processes.

SKILL SET

Research in the LTER program required an expansion of my skills in ecology to include extracting labile nutrients from soil, quantifying fungal and microbial biomass, working with radioactive isotopes to trace phosphorus translocation between litter cohorts, and making mass balance calculations. I have also stretched my skills in statistical analyses,

mostly through collaborations with others both inside and outside the LTER network. I have also learned how to analyze microbial communities using molecular methods through my collaborations with other researchers at LUQ.

One of the most valuable skills I learned through my collaborative research in the LTER program was how to effectively work with a large interdisciplinary team. I learned from Lawrence Walker's leadership of the "disturbed plant group" to elicit prospective titles for manuscripts or sections of manuscripts at the beginning of a collaborative project, get task and author commitments for each title, and then make adjustments to authorship as needed until the research is published. Those skills served me well in leading a self-assembled group of 34 mycologists in a 15-year project to revise the higher-level systematics of a fungal family (Lodge et al. 2013).

PERSONAL CONSEQUENCES

When living on a small island, contacts with researchers who are visiting to work in the LTER program are a critical part of our social network. The off-island researchers bring fresh perspectives, knowledge, and ideas, and represent various cultures. Parts of my holidays are often spent with our collaborators when they come to Puerto Rico, and I take time when we can to visit them in their homes and home institutions. My life would be much poorer without the social network provided by association with the LTER program.

CHALLENGES AND RECOMMENDATIONS

The most difficult aspect of research in the LTER program is the review process for renewal proposals. The funding for each site is generally only sufficient to maintain infrastructure, including some large-scale manipulations, long-term measurements, and a few critical key people such as data managers and site managers. Consequently, there is only a meager amount of funds for scientists and their students to conduct research or for costly cutting-edge research. In essence, funding for research in the LTER program goes more to support sites as a platform for other research proposals. This platform is quite valuable, but the evaluation of renewal proposals is influenced by reviewers who are biased toward short-term results and testing of cutting-edge hypotheses. It is a struggle each time to reinvent a site's program to meet the long-term goals of the program while simultaneously addressing the short-term bias of the reviewers.

The LTER network was designed to be used for cross-site analyses and comparisons, but there is little financial incentive to accomplish that goal. The funding of cross-site workshops that evolve from the All Scientists Meetings are helpful in fostering cross-site comparisons and publications, and there are some funds for students to work at multiple sites, but funding levels and incentives are insufficient to motivate and support cross-site experiments. Unless more resources are devoted to cross-site comparisons, I do not think that the LTER program will live up to its potential as a network.

CONCLUSION

My involvement in research in the LTER has not greatly influenced my approach to science or mentoring, but it has greatly expanded my skills and my opportunities for mentoring and for collaborative research. My early experiences in collaborative research at LUQ reinforced something I learned from watching my graduate student classmates: that if someone is not inspired by their research project, and they do

not experience "the fire in the belly," they will not bring their project or thesis to its successful completion. I think the LTER program provides a critical foundation for collaborative research. The most important skill I learned from my research collaborations in the LTER program was to negotiate agreements on commitments and expectations at the beginning of a collaborative project, and then revisit those plans on a regular basis. Cross-disciplinary training is critical to launching a successful career, not only in relation to the LTER program, but also in light of the complex ecological and social problems that we face with global climate change. I do not think, however, that the LTER program will live up to its full potential as a network unless the evaluation system and the funding structure are changed. I recommend that students and junior colleagues negotiate authorship agreements up front in collaborative research projects and seek opportunities for training in other disciplines whenever possible.

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