**Theme, Vision, and Goals**

Human health, food security, conservation and management, and recreation are all disciplines that rely on knowledge of biodiversity. At their intersection, many of the ecosystem services that society deems important — increased agricultural and natural resource production, water quality and fresh water abundance, and disease control (Rodriguez et al. 2006) — are directly correlated with biodiversity in both human-dominated (Wagg et al. 2014) and natural (Gamfeldt et al. 2013) systems. Assessing and conserving biodiversity, especially in our current era of anthropogenic change, will require biologists trained in a wide array of skills (Tewksbury et al. 2014), which are normally not integrated in single training programs, to generate the knowledge needed to effectively face today’s societal and scientific grand challenges.

Typical training efforts often produce researchers with deep taxonomic and evolutionary knowledge of one group but little training in how to broadly apply general biological principles, or workers trained in applied details without sufficient depth of knowledge of evolutionary or ecological contexts. Further, traditional and narrow training paths yield graduates lacking skills in the latest technology revolutionizing their fields, ranging from next generation sequencing abilities allowing detection of organisms from wisps of DNA in a stream or sequencing entire viral genomes in a day, drones allowing remote sensing of biodiversity data, and geographic information systems to allow precise mapping and correlation of abiotic factors with responses of organisms. Moreover, none of our training of potential leaders in these tools covers necessary skills such as project management. Our training is often focused on creating new academics: even though a substantial number of graduates go on to non-academic fields, these are often described as “alternate academic” paths, and programs do very little to train students for them.

Our strategy to remedy this is a new program that capitalizes on the University of Tennessee, Knoxville's academic expertise while also engaging with local and national partners. This combination of interdisciplinary emphases and experiential learning will not only address current biodiversity-related challenges, but also pave the way for next-generation biodiversity scientists to enter careers in alternative academic paths in partner or associated organizations. The call for incorporation of new technologies into the traditional realm of natural history has only recently been posed (Tewksbury et al. 2014). However, the benefits of experiential learning experiences have been well substantiated at the collegiate level, and include increased retention (Kuh 2008), abilities to solve complex problems (Batchelder and Root 1994), and increased student motivation (Tumlin et al. 2009).

Our program covers four modular areas. The first three include **1)** core biology training: areas such as ecology, evolution, genetics, and especially natural history; **2)** technological training: remote sensing, genomics, GIS; **3)** leadership and management training. The core biology training builds on existing courses but will also feature two-week intense field courses. The technological training will largely be delivered in workshops. Our faculty already offer a few workshops that can draw interest from hundreds of applicants; by streaming these online, we can reach many more trainees than the core set of students supported by the program. Tutorials and field courses also offer a mechanism for long term sustainability of this initiative through participant fees. For vocational training we will capitalize on relevant courses in project management and team building, including coordinating with colleagues on the creation of new courses. In modular area **4)**, trainees will participate in at least one internship with our partners, which will help build their professional networks and expose them to the management of concrete issues. Throughout the life of the grant, integration with our external partners will help us tailor training to meet key needs they identify. The overall goal is to graduate Masters and PhD students with the intent of pursuing careers in business, NGOs, or government: unusually for many biology graduate programs, especially those at liberal arts colleges (like that of one of our three collaborating departments), an academic career will be not be the target for our students upon entry, and we expect few to go down that path. Because our partners have provided indications of the skills needed to address their current needs, it is our hope that our students will become viable candidates for careers within partner or related organizations.

UT Knoxville is the ideal location to establish such a program. For biodiversity experts, we are already a key destination given our high regional biodiversity and existing groundwork to map it (e.g. All Taxa Biodiversity Inventory, which has mapped 19,000 species in Great Smoky Mountains National Park), research collections (TENN Herbarium housing vascular plants, bryophytes and fungi, UTK Fish Collection, UTK Caddisfly Collection) and faculty-led courses about fish, fungi, plants, reptiles, amphibians, birds, mammals and invertebrates. We have a tradition of collaboration with, and placement of graduates in, federal and state agencies, and NGOs such as The Nature Conservancy and the Tennessee Clean Water Network. Our technological skills are at the cutting edge, with expertise in environmental DNA monitoring, high performance computing, next generation sequencing, and use of drone and satellite imagery for addressing biological questions.

The three departments each bring unique strengths and weaknesses to the project. Ecology & Evolutionary Biology (EEB) brings a focus on ecological and evolutionary mechanisms, as well as expertise in fungi, plants, vertebrates, and some insects. Though it does have a substantial set of students move on to careers outside academia, like most science programs in Arts and Sciences colleges it does not do much preparation for this path. Entomology & Plant Pathology (EPP) extends the taxonomic expertise to arthropods and disease organisms and has rich connections with agriculture. Forestry, Wildlife, & Fisheries (FWF) maintains a focus on harvestable natural resources (fish, timber, recreational hunting) but far less of an emphasis on biological mechanisms or question-driven science.

*Context for added value*

Our programs track outcomes: for example, we have tracked placement of EEB PhD and Masters students for the past 16 years, and know placements for 127 of 135 graduates of that program. This baseline data will be useful in allowing us to measure the impact of this program. It also allows us to integrate program participants into alumni networks, especially with alumni outside academia. These data suggest that for our programs, academia remains the default outcome, with 83% of EEB PhD graduates either in a faculty role or in some other academic research position (often postdoctoral positions, especially for recent graduates, with the intention of moving on to faculty positions) and 50% for Entomology and Plant Pathology.

*Goals*

Our project has three main goals:

1. Produce STEM professionals who are interdisciplinary, technically savvy, and professionally literate.
2. Advance biodiversity research
3. Generate knowledge about innovations in graduate education approaches

In addition to published work on key needs (Tewksbury et al. 2014), we have surveyed potential employers for biodiversity STEM graduates for needed skills. Repeatedly, they indicated that knowledge of geographic information system software, experimental design, technical writing skills, and detailed expertise in one or more taxonomic groups was key.

**Education and Training**

The traineeship model has four main components at its disposal: 1) core coursework in ecology, evolution, statistics, GIS, and related areas, 2) two-week field courses focused on particular groups of organisms, 3) intensive workshops in skills, and 4) internships. We propose to use existing and new programatic elements to enable students, in consultation with their multi-disciplinary advisory committee, to select appropriate courses and experiences from all four components (Table 1). Both the Masters and PhD programs across the three department currently require 24 hours of course work (plus additional thesis or dissertation hours). All three deparments offer flexible curricular choices for graduate students that will integrate with the components of this new traineeship program.The **core coursework** builds on these existing UT courses spanning three modular areas. The core biology courses are supported by traditional graduate student offerings across departments ,spanning ecology, taxonomy, anatomy, physiology, evolution and conservation. Existing technological training courses include ENVE 561 - Climate and Environmental Informatics, GEOG 517 - Geographic Information Management and Processing, and EPP 622 – Bioinformatic Applications. Others coming on line soon include FWF 530 – GIS for Natural Resources. Courses in management and assessment, include EDAM 560 – Grant Writing and Project Management, ENMG 536 - Project Management, and ENMG 541 - Managing Change and Improvement in Technical Organizations.Trainees will pursue courses across each of the three types (ecology, technology, management/assessment). More targeted graduate courses depending on the needs of the trainees may also be utilized. Capitalizing on established courses helps make the program more sustainable after its funding runs out and exposes trainees to students and instructors from a variety of perspectives.

Table 1. Graduate Education Components

|  |  |
| --- | --- |
| Credit Hour Instruction | Totaling to 24 |
| Core Biology Credits | 9+ |
| Technology Credits | 3+ |
| Management/Assessment Credits | 3+ |
| Field Courses Credits | 3+ |
| Experiences |  |
| Skills Workshop | 2 PhD/1 MS |
| Internship | 1 |

**Field courses** are key ways to promote learning (McLaughlin and Johnson 2006) and UTK faculty have experience teaching in field courses for a variety of organisms. This piece constitutes a focal area of development. Efforts are currently underway to expand this effort at the graduate level (e.g. field courses integrating use of EEB’s field station outside Great Smoky Mountains National Park).

Each year trainees will also have access to **skills workshops,** which are 2-3 days of intensive learning, usually with both lecture and practical exercises. The workshops will be available online through streaming and by posting teaching materials (slides, exercises, scripts). This successful model is used by O’Meara through several NIMBioS tutorials on computing, phylogenetics, R, and genetics, as well as an NSF CAREER grant-sponsored course. For the biodiversity student trainees, O’Meara will offer two options based on tutorials he has run in the past: “High Performance Computing for Phylogenies” and “Computing in the Cloud: What Every Computational Life Scientist Should Know.” CoPI Staton is a certified instructor in Data Carpentry (Teal 2015), a vetted 2-day training curricula utilized worldwide for teaching data analysis and reproducibility principles. Customized curricula are available for ecology, genomics, and geospatial data approaches. Co-PI Staton will sponsor and co-teach a Data Carpentry workshop each year as well as continuing to offer her 2-day next generation sequencing and bioinformatics workshop on RNASeq.

Trainees at the MS level will participate in at least 1 workshops prior to graduation, and PhD-level trainees will attend at least 2. Courses will be updated yearly or replaced with new material to reflect state of the art approaches in biodiversity and the particular research needs of the trainees. Further options will be available through NIMBioS, which sponsors workshops for faculty, staff and students. Examples from the past 2 years include “Evolutionary Quantitative Genetics,” “Game Theoretical Modeling of Evolution in Structured Populations,” “Current Issues in Statistical Ecology,” and “Using R for HPC.” Assessment of domain knowledge at the beginning, completion, and a year after each field course and skills workshop will help highlight effective strategies and long term impact.

**Internships** will allow students to build networks outside academia and learn about the skills necessary for careers at places such as federal and state agencies, environmental consulting agencies, and more. Currently, FWF has well-established internship opportunities for its undergraduate majors, including opportunities with some of our partner organizations. At the graduate level, this constitutes a focal area of development, though a number of potential partners have expressed interest.

*STEM graduate population that will be served:*

This grant will serve four audiences. The first is funded trainees: 15 PhD or Masters students funded with $30K stipends (plus tuition and benefits) for two years each. These students will make up the core of the program. The next tier are other UTK graduate students in the affiliated EEB, FWF, and EPP departments as well as students in related groups such as Earth and Planetary Sciences, Genome Sciences and Technology, and Geography. These students will participate in one or more of the field courses or skills workshops; over the five year life of the grant; we anticipate training between 30 and 100 students. The third tier consists of external participants who would attend in person a field course or skills workshop, pay some tuition/fee but have this cost supplemented by the grant. These participants could be academics, especially graduate students, from other institutions, land managers, biocontrol workers, agency employees, and other non-academics. These experiences would deepen connections between the program and the broader community, and importantly expose core and affiliate students to people successfully pursuing careers outside academia. The fourth population is people remotely making use of teaching materials. The audience size for this is uncertain, but available metrics indicate it could be quite large: NIMBioS online video tutorials can have hundreds of views, and O’Meara’s course website for his NSF-sponsored flipped phylogenetics methods course, which was launched in January, 2016, has had 6,136 visitors to date from 94 countries.

*Internships*

A major aspect of training is placing students in internships. We have communicated with the following organizations for potential internships for our students and what training needs they see: the National Park Service, US Fish and Wildlife Service, US Forest Service, Tennessee Department of Environment & Conservation, Tennessee Wildlife Resources Authority, Huber Engineered Woods, the Nature Conservancy, Discover Life in America, and various independent environmental consultants. Moreover, we will be receiving assistance from \_\_\_\_\_ of the Tickle College of Engineering, who has coordinated with USGS for internships for their students (See Letter of Support).

**Major Research Efforts**

There will be three areas of catalyzed research. First will be research performed by students while studying at the University, both while funded as part of this grant and, for PhD students, while funded from other sources. Second will be research enabled through cross-disciplinary interactions fostered through this project. Third will be published research based on assessments of the program.

Students in this program will pursue research-based dissertations in areas relating to modern biodiversity. Most notably, the world faces a biodiversity crisis: human activities are driving some species to extinction, invasive species are a major economic risk ($70.4 billion for the agriculture in the US alone (Paini et al. 2016)), and the skills to identify critical species are being lost (Agnarsson and Kuntner 2007). Student projects depend on an overlap in interest between the student and her or his potential advisor. Some possible research programs include:

**Kaliz lab**: The evolutionary and ecological research in the Kalisz lab investigates forces that shape individual phenotypes and genomes, drive population level fitness and speciation, and alter standing levels of biodiversity within native communities. Possible graduate projects involve investigating mechanistic hypotheses centered on how anthropogenic factors, including habitat disturbance and overabundant deer, alter species interactions in forests and drive exotic plant species invasion and native species declines.  Current effort focuses on mechanism underpinning invasive species disruption of native plant mutualisms (i.e. AMF, pollination), physiological and demographic responses to invasion and the maintenance of native biodiversity.  These grad projects will leverage databases from GSMNP and other long-term field sites to address important conservation and management issues at national and regional scales. This can lead directly to careers in conservation organizations and state and national parks.

**Kwit lab**: His research interests include plant-animal interactions and bioenergy sustainability. Connections with partner organizations include common interests in assessing landscape change and silvicultural practices on pollination. Graduate students with field identification skills of pollinators interested in identifying pollen to species via DNA sequencing approaches to quantify pollen communities of specific pollinators could assist such efforts; so too could graduate students with DNA sequencing skills interested in identifying insects. These students could move on to careers in federal or state agencies or for agricultural businesses.

**O’Meara lab**: Research in this lab group uses phylogenetic methods to address key questions in macroevolution and ecology. Most notably for this grant, one focus of O’Meara and colleagues has been development and use of approaches to delimit species (O'Meara 2010), including cave fishes of the Eastern United States (Niemiller et al. 2011) and North American bats (Jackson et al. 2016). Such skills are key to being able to identify biodiversity, especially cryptic biodiversity that is of grave conservation concern. Students working on projects of this type could pursue careers in conservation, at non-governmental organizations or in state or federal conservation agencies.

**Staton lab**: This group builds software for developing websites that store genotype and phenotype data (the open source Tripal project). She is currently funded to expand this software base to a mobile device application and online website interface for ecological data sampling. The software will enable scientists to develop an ontology-driven data collection schema, deploy this across mobile devices for field data collection, upload their data to the cloud, and return to the lab to filter, sort, and share data from an intuitive map interface. Graduate students interested in programming could help with software development while field courses and student research projects could be used as test bed for the application. These students could move onto careers identifying genes of potential agricultural significance.

**Broader Impacts**

It is increasingly recognized that graduate programs in sciences should not focus on just churning out future faculty (Nature Editorial Board 2014), but few are configured for broader career outcomes. This project builds connections between graduate students and professionals outside academia while training students for a wide variety of positions focused on biodiversity. The addition of necessary practical skills such as project management and assessment will position graduates to be strongly competitive and ultimately more successful in industry or academia. The open nature of the training also pushes scientific knowledge out into the public domain where professionals can learn from it, fulfilling a classic role of land grant institutions. Sponsored student research projects will span a variety of biodiversity questions, likely ranging from alpha taxonomy to modeling population movement with climate change to studies of urban ecology.

On a broader scale, despite some clear advantages of academia as a way of training more academics for knowledge creation and dissemination, it is increasingly being recognized as problematic. It often involves great financial uncertainty until people enter their late twenties or early thirties, and generally requires a willingness to move away from one’s community for increasingly elusive employment. Graduate programs are paying increasing amounts of attention to this, and may now include a few seminar speakers from outside academia, a discussion group on alternative careers, or similar small scale programs. Our approach is radically different: with this program, the “alternate” career is academia – our goal is to get our students out into the world working with real world biodiversity questions. Both the academic and non-academic paths have great value, but the latter needs much more emphasis. The triumphs and failures of this program, which will be communicated throughout the grant, will help be a prototype other programs can adopt when they choose to bring the same rigor and attention to non-academic paths as they do to academic ones.

Finally, this is an unprecedented time of threats to biodiversity. We desperately need more research on threats and how to mitigate them, but we also need muddy boots on the ground to implement best practices. Students from our program will have deep knowledge of biodiversity, ecology, and evolution, while also having skills in project management and contacts with NGOs and private companies required to effect real change.

**Organization and management**

The faculty involved in this grant as PIs and Co-PIs will comprise the leadership team. They already are fairly well-connected (Kwit spans two involved departments, O’Meara has served on committees for PhD students of Moulton and Kalisz, Staton, Kalisz, and O’Meara are all affiliated with NIMBioS, and so forth). O’Meara as PI will help ensure the project meets its goals, but the team member who will serve ideally as a bridge between communities, both in and off campus, will be Kwit. Kwit’s recent research spans areas from warbler winter habitat management in the Bahamas, bioenergy sustainability of switchgrass as a biofuel crop, oak savanna restoration, and animal-mediated seed dispersal, much of which has utilized collaborative support from state and federal agencies and NGOs. He is also a joint appointee in the Department of Forestry, Wildlife, and Fisheries in the College of Agricultural Sciences & Natural Resources and the Department of Ecology and Evolutionary Biology in the College of Arts and Sciences, both at the U. of Tennessee. He thus would be the ideal resource for students in this program, and will be receiving a month of summer salary per year to enable his time to be used for this. We envision hiring a half time staff person to serve as Project Coordinator. This person would report to Kwit and O’Meara, and would be responsible for overseeing steady progress of the students and handling connections between them and internship opportunities. Staton will lead the development of tutorials and workshops, given her experience with this in the past, assisted by O’Meara. Evaluations will be handled by East Main Evaluation and Consulting, LLC: Dr. Barbara Heath will be leading this group, but may be assisted by staff or interns within her group.

A sense of community will be fostered organically through overlapping courses and workshops taken by students and taught by faculty. We will also have two social gatherings per year: one in February at the time of recruiting, and one at the end of the academic year. These will feature core students and their families, recruited applicants (in Feb.), the leadership team, and other members of the involved departments. We will also create a web site and chat room for the project. The chat room especially will allow participants to discuss issues as they arrive, celebrate successes, and ask for advice. The technology we would use today is a service such as Slack or Gitter; given the anticipated start date for the grant approximately 1.5 years in the future, these particular services may have been replaced but we will use the equivalent at that time.

Students in our program will be full members of one of the three collaborating departments. Our plan is to set a floor such that each department receives at least 25% of all students and thus have buy in. We will only admit students if we can assure them of funding until graduation (as long as they meet adequate progress guidelines). For Ecology & Evolutionary Biology, this means that after their NRT funding expires Masters and PhD students will continue on guaranteed TA or RA lines, until graduation, a model already used for trainees in our NIH PEER program. For Entomology & Plant Pathology and Forestry, Fisheries, & Wildlife, which have few TA lines, most admitted students will be Masters students expected to graduate in two years unless their advisor has other sources of funding, and PhD students therein would require stipend, benefits, tuition and fees to be covered by their advisor.

***Coordination with administrators***

A training grant will fail without institutional support. At the level of department heads, we have one department head as a Co-PI on the grant, an associate head as PI, and have had frequent contacts in developing it with heads of the other two departments (with particular concern for how participation in this grant affects tenure considerations for Co-PIs who are junior faculty). We have also met with Associate Dean Brothers regarding this grant and will continue to consult with him moving forward.

We will coordinate with higher level administrators in two ways. The first is informal: we will invite them to our two annual social events so they can form connections with our students and our external partners. The second is through an annual joint meeting with heads of the three collaborating departments, grant personnel, the Dean of the Graduate School, the Associate Dean for Academic Programs at the College of Arts and Sciences, and the Associate Dean at the College of Agricultural and Natural Resources. One week before the meeting, all the involved parties will receive a written report listing grant goals for the previous year, delivery of those goals, goals for the next year, University, College, and Department policies or procedures that have helped or hindered the achievement of those goals. For example, our Office of Institutional Research Assessment currently does a poor job tracking graduate outcomes; while the involved departments are compensating for this individually, this is an institution-wide problem that should be addressed.

***Project roles***

* *Program coordinator*: half time position for a staff member. She or he will be involved in matching students to internships, tracking progress, and preparing reports. A half time position should be adequate for the program’s scope, plus promotes sustainability in the future.
* *PI O’Meara*: He will oversee the project to make sure it delivers on its goals, as well as teach in workshops.
* *Co-PI Kwit*: He will be the key contact person for students and external members. He can fluidly move between the worlds of academia and applied work.
* *Co-PI Staton:* She will arrange for and teach in skills workshops, as well as identify curricular holes that will need to be filled with new courses.
* *Co-PIs Moulton, and Kalisz*: They will teach in workshops. Their involvement is part of UT’s investment for sustainability. They are both fairly senior faculty (Kalisz also currently serves as EEB department head).
* *Affiliate faculty*: Faculty who seek to enroll students through this program will have to first go through a training session on alternative academic careers and cross-mentoring. The need to do this before students can be accepted will be an inducement to widespread training in this area.
* *Core students*: These will be the funded students who will engage with the program, its training, and internships.
* *Affiliate students*: These are other students at the U. of Tennessee who will take classes through this NRT.
* *External students*: These are members of the community who would take workshops through the NRT.
* *External internship mentors*: Partners at local companies, NGOs, and government agencies who will host students.
* *East Main Evaluation and Consulting, LLC*: Assessment of project outcomes.

***Sustainment plan***

Sustaining the program after the conclusion of NSF funding is key. First, the involved departments will continue funding the NRT trainees in the same manner as regular trainees, assuming adequate progress, once the grant ends. The long term vision is that the this new traineeship gradually becomes integrated into regular graduate training: as faculty and students see the benefits of biodiversity training for careers outside academia, cultural expectations of the programs will shift. In the same way training for academic careers is currently the default, and which thrives despite lack of NSF funding explicitly for this, we expect our training model to diffuse through the relevant programs. Similarly, tasks that will be undertaken by the Program Coordinator to start will devolve to the graduate coordinators of each department. Similarly, the paradigm shift in training approach, including partnerships with potential employers through internships, will be continued as faculty, students, and partners experience the benefits of this. Cross-disciplinary mentorship of students will foster research projects and grant proposals spanning the included departments (and this will be measured as part of the assessment process).

**Recruitment, Mentoring, and Retention**

This NRT has a two-fold strategy to recruitment and retention: providing student access to the program, ensuring that potential graduate students from all walks of life are aware of the opportunity to apply, and creating an environment of inclusion with enrichment experiences to maintain retention and facilitate attainment of students’ goals.

***Recruitment:*** This NRT program will work closely with UT’s Graduate School, which supports 55 doctoral degree and 76 master’s degree programs, to recruit a diverse population of students. We will join Graduate School representatives as they participate annually in graduate school fairs across the Southeast and at national conferences such as the annual Society for Advancement of Chicanos/Hispanics and Native Americans in Science (SACNAS) conference, which has 3,600 attendees from a wide variety of backgrounds, as well as professional conferences. In addition, we will provide printed and online promotional materials about the NRT Traineeship, which will be disseminated in these venues and others. Our focus on training students for careers outside academia, which can result in higher starting salaries (\_\_\_\_\_\_) and far less uncertainty in career outcome and locale after graduation (\_\_\_\_), will help broaden our set of participants (\_\_\_\_\_\_). We will also leverage the Graduate School’s recruitment activities that focus specifically on underrepresented students, such as campus visits from TRIO, McNair, and NSF LSAMP programs throughout the region. Finally, we will work with colleges throughout UT that engage in decentralized recruitment activities taking place at the departmental level. Each year, we will sponsor two major events for students and prospective students, one during a graduate recruitment weekend in early spring, focused on prospective students, and the other at the end of the spring semester, focused on celebrating graduate students’ progress.

Institutional support will come from Associate Dean of the Graduate School Ernest Brothers, who is an expert in graduate student diversity and mentoring. He recently presented a workshop, “Diversity and Mentoring in Academia,” to Oak Ridge National Laboratory and a workshop, “Strategies for Mentoring Diverse Graduate Students and Faculty” to UT’s Psychology Department. He will present similar workshops for our faculty, to set the stage for a welcoming environment upon NRT Trainees’ arrival in Knoxville. Brothers is on several boards related to diversity and graduate student training, including UT’s NIH-funded Program for Excellence and Equity in Research (PEER).

***Mentoring and retention*** will build on the strengths of our programs. For example, EEB has tracked long-term placement of our graduate students over the past 16 years; out of the Masters students, 27 (52%) have gone on to careers outside colleges and universities, at jobs ranging from the US Forest Service to education coordinator at the Jackson Zoo to program director at the New York City Parks Department to high school biology teacher. The EEB department has also created its own tracking software to monitor grad student progress towards degree and to automatically highlight potential issues while building up a long term, secure, database of progress and outcomes. Data-intensive approaches such as these can identify problems early while also making programmatic assessment more rigorous for reports to grant agencies or higher administrative levels within the University. Core trainees will be mentored through standard committee structures but also through annual meetings with the trainee program coordinator (one of the core faculty). The initial meeting will involve the creation of an individual development plan with concrete goals; this plan will be re-evaluated every year. Students will also be mentored through the informal networks fostered by their internships in their second year of grant funding.

Co-PI Kwit will oversee Trainees’ mentorship and mentoring activities to be developed. One of these activities is a weekly discourse session, modeled on a PEER initiative to increase the number of exceptional underrepresented students graduating with doctoral degrees in STEM disciplines at UT. Another activity will help students develop an individual development plan and monitor their progress toward accomplishing their goals.

Retention: We will create a community of scholars within NRT cohorts and connect students with other programs at UT. The goal is to create experiences that further each student’s professional aspirations. We will leverage existing resources, such as UT’s Multi-Cultural Graduate Student Organization, which connects members of underrepresented groups across campus, to help students connect with others. We hope to improve on UT’s current graduate student retention rate, which is \_\_\_\_, by increasing that rate to \_\_\_ in our three disciplines. Working with the Graduate School’s new customer relationship management system, we will be able to identify where students were recruited, and when they applied, were accepted, enrolled, and matriculated. Such a system enables the NRT program to automatically respond to students, providing immediate feedback.

**Performance Assessment / Project Evaluation**

External evaluation will come from East Main Evaluation and Consulting, LLC, a group with experience with evaluating NSF-funded and other projects, including serving as the external evaluator for the iPlant / CyVerse projects ($94.1M in total). The evaluation of this Research Traineeship Program will follow a process and outcome framework. This evaluation approach will provide a comprehensive model to analyze the project activities and gather data for the program effects. Within this process and outcome framework, a logic model will be developed in coordination with the project team prior to submission of the full grant proposal and will be used to represent the sequence of steps between program services and outcomes. Key metrics will be annual progress towards degree, trainee satisfaction, and knowledge assessment before and after key training activities such as workshops, courses, and internships. Internship hosting organizations will be asked for their perspective on the performance and marketability of trainees through this program (as has been done for undergrad internships, i.e., Gault et al. (2010)) as well as qualitative impressions. This will allow fine tuning of training while the first cohort of students is still progressing through the program. We will also survey students after graduation, both for placement and to learn their impressions of the efficacy of the training. Competencies assessed will include biological domain knowledge, understanding of relevant technologies (such as modern sequencing methods and use of remote sensing data), and competency in leadership and management skills required for successful careers.

We have three goals for the assessment. The first goal is to allow data-driven improvements in the program overall: adjustments in recommended timing of events, discovering which internships provide the best outcome, changing the mentorship models. The second is to provide data back to NSF in our annual reports to allow them to adjust the NRT program as a whole. Finally, we hope the training model we develop will become a prototype for others to adopt. These adopters could be other programs within the University that seek to combine scientific training, leadership skills, and experiential learning, as well as programs located in other biodiversity regions. To help with this goal, all reports will be posted publicly, and publications for peer review will be prepared and submitted to disseminate the process and related findings of the training program.

**Recent Student Training Experiences**

Over the past five years, PI O’Meara has had four graduate students in his lab. All are still currently enrolled: two are on schedule to receive their PhD in ecology and evolutionary biology as well as a Masters in statistics this semester, another recently received a DDIG award and is on track for graduation on schedule, and a fourth recently took his PhD qualifying exam. The two students planning to finish this semester have decided to pursue careers outside of academia, and enrolled in and successfully completed a program to earn a Masters in statistics while in a PhD program with this intention. They both had internships at the Tennessee Valley Authority (one received an offer of a job once she graduated), and one has also interned with our athletic department analyzing academic progress of athletes. Half of O’Meara’s students identify as women, and one identifies as Hispanic. O’Meara also serves on approximately one-third of graduate student committees in the Ecology and Evolutionary Biology department and has also served on student committees in Entomology, Earth & Planetary Sciences, Microbiology, and Genome Sciences and Technology. O’Meara has also served on EEB’s graduate admission committee and now is associate head for graduate affairs in the department; as part of this, he has run training for graduate students in grant writing. As associate director for postdoctoral training for NIMBioS, he has also organized training sessions for postdocs pursuing careers in biology, math, and statistics.

Co-PI Kwit has had four graduate students in his lab over the past five years. All are still currently enrolled: two are on schedule to receive their PhD in ecology and evolutionary biology, another is a co-advised natural resources PhD candidate in FWF, and a fourth is pursuing a M.S. in wildlife and fisheries science in FWF. The latter is pursuing a career outside of academia, and is about to participate in an internship with the National Parks Conservation Association. Three of co-PI Kwit’s graduate students identify as women. Over the past two years, co-PI Kwit and one of his EEB graduate students have served as undergraduate mentors at the University of Virginia’s Mountain Lake Biological Station, a NSF-funded Research Experience for Undergraduates (REU) Program. Kwit currently serves on graduate student committees in FWF, EEB, Plant Sciences, and at other universities.

Over the past three years Co-PI Staton has trained three graduate students in her lab. One graduated with a MS degree in Entomology and Plant Pathology; the other two are currently enrolled and on schedule to receive PhDs; one in Entomology and Plant Pathology, the other in Genome Science and Technology. The graduated MS student is currently working as a staff scientist at a National Laboratory. Two of the three students self-identify as female and two are foreign nationals. Staton serves on 14 graduate student advisory committees across 5 departments: Energy Science and Engineering; Genome Science and Technology; Entomology and Plant Pathology; Animal Science; and Ecology and Evolutionary Biology. Co-PI Staton’s position is unique in that her appointment specifies 50% time devoted to providing bioinformatic and data analysis expertise and consulting for faculty, staff and students. This positions her to successfully build inter-disciplinary programs spanning multiple departments and to focus significant attention on developing and running workshops and courses for broadly needed data analysis techniques.

**Results from Prior Support**

Agnarsson, I., and M. Kuntner. 2007. Taxonomy in a changing world: Seeking solutions for a science in crisis. Systematic Biology **56**:531-539.

Editors. 2014. Editorial: There is life after academia. Nature **513**:5.

Gault, J., E. Leach, and M. Duey. 2010. Effects of business internships on job marketability: the employers' perspective. Education+ Training **52**:76-88.

Jackson, N. D., B. C. Carstens, A. E. Morales, and B. C. O'Meara. 2016. Species Delimitation with Gene Flow. Systematic Biology:syw117.

McLaughlin, J. S., and D. K. Johnson. 2006. Assessing the Field Course Experiential Learning Model: Transforming Collegiate Short-Term Study Abroad Experiences into Rich Learning Environments. Frontiers: The Interdisciplinary Journal of Study Abroad **13**:65-85.

Niemiller, M. L., T. J. Near, and B. M. Fitzpatrick. 2011. Delimiting species using multilocus data: diagnosing cryptic diversity in the southern cavefish Typhlichthys subterraneus (Teleostei: Amblyopsidae). Evolution **Accepted pending minor revisions**.

O'Meara, B. C. 2010. New Heuristic Methods for Joint Species Delimitation and Species Tree Inference. Systematic Biology **59**:59-73.

Paini, D. R., A. W. Sheppard, D. C. Cook, P. J. De Barro, S. P. Worner, and M. B. Thomas. 2016. Global threat to agriculture from invasive species. Proceedings of the National Academy of Sciences **113**:7575-7579.

Tewksbury, J. j., J. G. T. Anderson, J. D. Bakker, T. J. Billo, P. W. Dunwiddie, M. J. Groom, S. E. Hampton, S. G. Herman, D. J. Levey, N. J. Machnicki, C. M. del Rio, M. E. Power, K. Rowell, A. K. Salomon, L. Stacey, S. C. Trombulak, and T. A. Wheeler. 2014. Natural History's Place in Science and Society. BioScience **64**:300-310.