

THREATENED SPECIES AND ECOSYSTEM RESTORATION CENTER (TSERC)
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1. Description of the discovery opportunity.

Many plants native to the U.S. are being threatened by insects, disease, habitat loss, invasive species, excessive deer herbivory, and climate change. Likewise, entire plant assemblages such as temperate forest understories have become depleted, isolated, limited in ecological functions, and lacking resiliency to global change due to past land use and current stresses. The disparate, cumulative nature of these threats requires compound strategies focused at different scales of biological complexity, ranging from genetic modifications of individual species and genetic diversity analysis of populations, to propagation and augmentation of threatened populations and communities, to management of invasive species.

We propose a novel cross-scale approach to buffer threatened species and regional ecosystems against contemporary stressors with the overarching objective of restoring and sustaining viable populations and ecosystems. This proposed Threatened Species and Ecosystem Restoration Center (TSERC; figure below) will integrate across scale and discipline the restoration of Keystone Species, Regional Diversity, and Rare Species, accomplished through innovative research, educational programs, and partnerships with key organizations and agencies.

KEYSTONE SPECIES	REGIONAL DIVERSITY Serai forests, old fields, brownfields, and wetlands	RARE SPECIES
Research:	Factors affecting success and limitation of potential restorations	
Biotechnology	Restoration Ecology Invasives, Mutualists Ecological Survey and Monitoring	Propagation
	Facilities and Proving Grounds Greenhouses, Arboretum, Herbarium, Forest Properties and Waste Beds	
	Outreach to scale-up region-wide restoration with public and private partners: Government, Industry, Academics and Foundations	
	New Academic Programs M.P.S. Conservation Horticulture; Certificate Program in Native Plant Conservation	

Keystone Species: We will use the successful American Chestnut Research and Restoration Project as a template to develop restoration efforts for other threatened keystone species. The American chestnut provided vast ecological services, economic value, and social benefits until an invasive pathogen killed over three billion trees, rendering the species functionally extinct across its former range. In an historical precedent, biotechnology has been successfully applied to the American chestnut with the specific objective of large-scale restoration in natural ecosystems. Apart from the biotechnological

advances to develop disease resistance, the long-term restoration of American chestnut includes public engagement and citizen science, overcoming regulatory hurdles, and tapping traditional and non-traditional funding. Efforts are already underway on American elm and fund-raising has commenced for rescuing the Ozark chinquapin. Native ash species, eastern hemlock, black walnut, and various oak species are all threatened by exotic insects or pathogens and present similar opportunities for rescue. The continued influx of novel invasive species and the ever increasing threat of climate change make such effort imperative if forest ecosystems are to remain fully functional.

Rare Plants: Understanding the nature of the threat/s to rare plants is a critical first step to their conservation. Their eventual restoration depends on developing propagation tools and planting in new sites or augmenting existing populations. Such efforts may only succeed if done in conjunction with restoration of degraded habitat and removal of non-native competitors. Consideration of climate change in augmentation and restorative efforts is increasingly urgent as few of the thousands of federally-listed plants receive sufficient, if any, funding for this badly needed research and application. Without that knowledge, conservation of land alone will be insufficient for preventing extinction of these imperiled species. We will use our success with the American hart's-tongue fern (AHTF) as a proof-of-concept of our ability to protect, conserve and restore rare species. AHTF is a federally-listed rare fern, but restoration is challenged by low genetic diversity. Our group has developed an augmentation strategy using the most genetically diverse individuals for reintroduction, an approach that has shown early promise. We plan to expand this project to include Leedy's roseroot and Houghton's goldenrod, as well as other rare but not yet listed species like the fragrant fern. Conservation and restoration of species such as AHTF will be imperiled if underlying drivers such as proliferation of invasive species are not addressed. Integrating best management practices for invasive species into restoration efforts will be critical to success of the TSERC mission.

Regional Diversity: The legacy of regional land use has depleted soil seed banks and many dispersal-limited native understory plants have been unable to recolonize after more than a century of forest succession. Our pilot studies have demonstrated that these forest understory species can be restored to post-agricultural forests through direct seeding and vegetative transplants. However, impactful, region-wide forest ecosystem restoration will require large-scale production of genetically diverse plant materials of known provenance to be distributed to a large network of citizen scientists and volunteers.

2. Description of degree programs and how new programs will better position ESF students. TSERC will strengthen many of our core EFB undergraduate and graduate programs, particularly in areas such as Ecology, Conservation Biology, and Plant Science and Biotechnology. It will also provide service learning and leadership opportunities for our students including herbicide applicator training, plant propagation and nursery management. We will develop an MPS degree program in Conservation Horticulture geared towards understanding of the growing requirements of rare and threatened plants, propagation techniques, greenhouse maintenance, and launching a nursery business. We will also offer a certificate program on native plant conservation, based on participants taking five core, on-line courses in conservation and plant propagation. ESF has an underutilized quarantine facility well suited for evaluating potential biological control agents for invasive plants, an important applied discipline where the college has had little historical connection. Developing biological control programs in-house will provide students with practical, hands-on training in a field that provides the only large scale practical means of managing many established invasive species.

3. Agencies, partners & funding entities interested in funding the projects in the initiative area. Funding for the Chestnut Project from many sources over the last 5 years was approximately \$4,000,000, with ~\$1.4M of that coming in the last year. The following examples show only some of the major donors that are likely to fund the initiative - USDA NIFA BRAG program, American Chestnut Foundation (National

and NY Chapter), and Crowdfunding campaigns and direct private donations. A few donors for the projects on AHTF and Regional Diversity that will be tapped for the initiative include Department of Environmental Conservation, Cooperative Endangered Species Conservation Fund, and Great Lakes Research Initiative. The already existing partnership with the New York Natural Heritage Program and emerging partnership with NatureServe will allow us to formally connect to the dozens of scientists and professionals devoted to related plant conservation issues in New York and North America.

4. Description of how the initiative will expand current or create new partnerships.

The initiative fits with the focus of the Wyss Foundation and Richard King Mellon Foundation. Current and other future partnerships include organizations such as The American Chestnut Foundation, The Long Now Foundation's Revive and Restore, Ozark Chinquapin Foundation, Oak Ridge National Lab, New York Botanical Gardens, Missouri Botanical Gardens, Cornell Alliance for Science, Forest Health Initiative, ESF Center for Native Peoples and the Environment, NYS DEC, US Forest Service, US Fish and Wildlife Service, USDA, EPA, and FDA. Tug Hill Tomorrow Land Trust and Finger Lakes Land Trust and nature centers (Baltimore Woods, Town of Skaneateles Conservation Area), NY Forest Owners Association have been active partners and will likely be involved in the initiative. NY DEC Lands and Forests, and the Finger Lakes National Forest have partnered on research and will likely be interested in ongoing restoration efforts, especially with decisions on future management of maturing conifer plantations. Numerous rural school districts will likely be interested, i.e., the chestnut project has been involved in several primary and secondary school programs, and we plan to expand to include the other components of the initiative.

5. Description of how the initiative will increase the use of ESF assets beyond main campus. The rare and threatened species that will be propagated in the lab or greenhouse will require field-acclimatization prior to their use in restoration efforts. We plan to utilize the Lafayette Road Experiment Station (LRES) for such activity. The American chestnut project is already utilizing the LRES for growing saplings, as well as the conducting experiments at the Tully Field Station and Heiberg Memorial Forest (HMF). In-situ 'forest gardens' can be developed at LRES and HMF. This begins to approach some of the natural variation in regional soil conditions. With future funding, these field sites may be enhanced as in our previous proposals to purchase the abandoned Lafayette Golf Course and develop new programs involving HMF (examples shown in: <https://www.esf.edu/chestnut/seedgrant/>).

6. How initiative will inform policy decisions, enhance ESF's reputation and have a global impact.

The initiative, which capitalizes on the successful track records of the participants, will put ESF at the forefront of science-based plant conservation and restoration, both nationally and globally. The participants have extensive expertise in their appropriate project areas and their research publications have been the basis for some of the policies in the recovery plans for many of the rare and threatened species. The regional public outreach to volunteer restoration and citizen science groups will increase ESF's public exposure. TSERC is unique in its focus on three integrated components (keystone species, rare plants, and regional community diversity) in comparison to other centers that largely focus on single components.

7. Description of new investments required to move initiative to financial sustainability by year four.

We will recruit a Development/Liaison Officer dedicated to the mission of TSERC to (a) identify and solicit philanthropic funds from individual and institutional sources, and (b) facilitate communication and cooperation between field restoration programs and Indigenous people communities. Each of the three components will require a Postdoctoral Fellow to implement research projects to address the critical issues currently faced by the components to solidify the validity of our approaches to restoration.

Species and Ecosystem Restoration Science Center (SERSC): Transformative research coupled with an experiential degree program for our changing world (Farrell, Powell, Fernando, Leopold, Schummer, Stella, Volk, Ettinger, Kroll, Parry, McGee)

1. Project feasibility statement containing two key items

(A) Description of the initial start-up of the project: As per the request of the Discovery Grant Committee, the SERSC combines our two synergistic pre-proposals to integrate novel restoration science with a transformative academic program through a transdisciplinary and multiscale approach. It capitalizes on the successes of current participants and enables inclusion of all academic departments on campus which are directly and indirectly engaged in restoration research, education, and outreach. The SERSC will transform how students learn about ecosystem restoration science and on-the-ground delivery of restoration projects. We will increasingly and adaptively integrate research, education and outreach such that students are deeply engaged in our transdisciplinary research, and these research activities will feed directly back into the application of on-the-ground restoration projects. Initial start-up needs include hiring one Center Coordinator (research, integration of Program into research) and one Program Coordinator (curricula development, integration of students into restoration deliver) both at the level of a Senior Research Assistant, a media and web designer to market the center and program, and a Development Officer dedicated to SERSC. We expect that our planned marketing strategy and novel degree program in Restoration Science will initially attract a mix of 50 new doctoral, Master's, MPS, Honors, and undergraduate students per academic class. We further anticipate our collaborative approach to scientific inquiry will greatly enhance grant and philanthropic opportunities.

(B) How the project will grow into a substantial & self-sustaining program beyond the seed period: We are not aware of any single institution that uses the array of restoration techniques on threatened plant and animal species and their habitats that are the foundation of SERSC, and concurrently engages the number of students anticipated to participate in the academic program. We believe that our unique academic program and integrated research at the center will become a flagship, show-casing and building on the core tenets of SUNY ESF. As such, enrollment will grow to help sustain the College, and the inclusion of on-the-ground restoration projects will be self-sustaining through FTEs charged on grant projects and progressive philanthropy. Integrating research grants (e.g., NSF), foundations, and philanthropy with positive outcomes of restoration ensure the SERSC remains viable. As successes accumulate, SERSC will attract increasingly larger donors and foundations who want to support our highly innovative and comprehensive approach to improving our world. Given our positive track record of grantsmanship and culturing philanthropic relationships, this proposal is a sound investment with low risk.

2. Statement regarding how the discovery idea is transformative with both general and more specifically with respect to research and education programs at ESF: The SERSC is transformative because it deeply integrates the training of the next generation of professionals with ongoing research to deliver increasingly effective ecosystem restoration and environmental outreach. The Program is novel in that components will integrate ethics, leadership training, environmental studies, conservation biology, wildlife science, construction management, engineering, chemistry and design. Research by SERSC into restoring and thereafter conserving keystone and rare species and plant and animal diversity will link directly with the Program to deliver restoration. In turn, students will have ground-breaking knowledge transferable to careers in conservation, making ESF graduates the best-of-the-best at restoring degraded ecosystems, ensuring a healthy planet for people, and restoring ethics into how people interact with their environments.