**8. Broader Impacts**

The research will train 3 postdocs, including one who will serve as PI for the proposal and gain experience in leading the effort. It will also train 2 graduate students, and ~12 undergraduates, at the intersection between macroecology and evolution, and across microbes to macroorganisms.

We will use the rich natural and dynamic landscape of Hawaii, and the acute environmental issues affecting the environment, to build a program of education and outreach. The PIs are already well positioned for such activities. The primary areas we plan to develop are:

1. Experiences for undergraduates and Masters students. Building research experiences for undergraduates and Masters students from both the University of Hawaii Hilo (minority-serving, 24% Hawaiian) and the University of Hawaii Maui College (also minority-serving, 37% Hawaiian). At the University of Hawaii Hilo, we will connect with the Ecology, Evolution and Conservation Biology (EECB) and Tropical Conservation Biology and Environmental Science program (TCBES, <http://tcbes.uhh.hawaii.edu/>); Gillespie is already an Affiliate Faculty member of TCBES. The EECB and TCBES Programs give high priority to the recruitment and training of students from groups under-represented in sciences with an emphasis on Native Hawaiian and Pacific Islanders. These efforts will be facilitated through the Pacific Internship Programs for Exploring Science (PIPES) program (<http://www.uhh.hawaii.edu/uhintern/>), a UH Hilo program designed to connect underrepresented undergraduate students, especially Native Pacific Islanders, to research internship opportunities relating to environmental issues in Hawaii; we will recruit undergraduates through this program (see letter attached). The research will involve each of the undergraduates coming out into the field with researchers involved in the project. We have already established close ties with Cathy Davenport, a faculty member at the University of Hawaii Maui College (see letter attached). The students will assist in field sampling at specific locations associated with the main sampling locations for the overall grant program. Specific projects that the students could conduct are as follows (i) comparison of species diversity of key groups of arthropods on young versus old lava flows; (ii) relationship between substrate age and diversity of targeted arthropod species; and (iii) analysis of the effects of forest fragmentation (natural and human) on species diversity of targeted arthropod species.
2. Experiences for High school and Middle School students. The USDA Forest Service co-leads, with the University of Hawaii at Manoa, a “Teaching Change Program”. This program features over-night immersive learning experiences to students by bringing students to natural areas of Hawaii Island. The current two-day curriculum focuses on linking phenology, conservation biology, and climate change on the island of Hawaii. Each month students visit a site to: (*i*) learn about native forest ecosystem ecology, including disturbance regimes and the general concept of change; (*ii*) learn about human-induced climate change and its potential impact on native ecosystems; (*iii*) measure plant phenology and publish these data with the USA National Phenology Network; and (*iv*) participate in native forest bird research. With monthly trips, this program is generating a unique tropical montane forest dataset on plant phenology and exposes students to: (*i*) native ecosystems that they would never otherwise have the opportunity to visit; (*ii*) the concept of plant and avian phenology and its utility for monitoring native ecosystems; and (*iii*) the concept of change, including anthropogenic climate change. Over the past four years the program has served 400+ students. The program has a particular focus on underprivileged and underrepresented youth from Hawai‘i. It also provides Teacher Training Workshops for local teachers and offers annual Conservation Career Days for students and their families to learn about professional and educational opportunities in Hawai‘i in conservation biology and natural resource management to inspire and empower the next generation of land managers in Hawai‘i.
3. Land Management Professionals. Fieldwork in Hawaii will be timed to coincide with the annual Hawaii Conservation Conference, the largest gathering of people (>>1,000 participants) actively involved in the protection and management of Hawaii’s environment (see <http://hawaiiconservation.org/>). The goal of the conference is to foster interaction between natural resource managers and the scientific community. In addition to holding a workshop to present and discuss our results at the conference, we plan to have one afternoon of round table discussion for the local community on the island of Hawaii, allowing a smaller group from university, state (DLNR), private (The Nature Conservancy of Hawaii), and federal (USGS, USFS, USDA, USFWS) agencies, and others, to discuss the work, its results and significance.

Besides working with local communities in Hawaii, we also plan to make use of avenues for outreach and education in Berkeley. We plan to develop a community of researchers as we have done in the past, that includes postdocs, graduate, and undergraduate students. In addition, we plan to:

1. Work with staff at the UC Berkeley Natural History Museums in the development of material for the *Understanding Evolution* (<http://evolution.berkeley.edu>) web site, designed for science teachers of all grade- and experience-levels. The system, which couples elements of evolution and ecology, field and laboratory, theoretical and empirical, provides an opportunity to convey some essential yet complex concepts in a relatively straightforward manner.
2. Use the forum provided by LBNL’s Open House for connecting to the local community (http://www2.lbl.gov/openhouse/) and especially the Science at the Theater (<http://uctv.tv/scienceatthetheater/>) events.

**9. Results of Prior NSF Support**

**Chase**: DEB 0949984 *Mechanisms of species-area relationships in Ozark glades.* 2010-2015, $748,046.00 (co-PI; Tiffany Knight, PI). Intellectual merit. The observation that larger areas typically support more species is the basis for the species-area relationship, one of the oldest and best known relationships in ecology. Nevertheless, the mechanisms underlying this relationship remain poorly understood. Specifically, the lower diversity found in small habitats is often a consequence of there being fewer rare species in those habitats than would be expected based on sampling. This grant funded a long-term, large-scale experiment in experimentally restored Ozark Glade communities. Population and community-level patterns were monitored, providing important implications for understanding, and trying to mitigate, biodiversity loss from small habitats, especially loss of rare species. Broader impacts. The primary impact of this research outside of basic understanding of restoration ecology principles was to engage cohorts of undergraduate and high school students (many from underrepresented groups) in genuine research experiences at the field station. More than 50 such students participated in research in these glades over the course of the experiment, as well as 5 PhD students and 3 postdoctoral fellows. Papers to date ([Burkle & Knight 2012](#_ENREF_4); [Chase & Knight 2013](#_ENREF_5); [Powell *et al.* 2013](#_ENREF_16); [Schuler *et al.* 2015, with 6 others currently submitted or in revision](#_ENREF_18)).

**Gillespie**: DEB 1241253 *Dimensions: A community level approach to understanding speciation in Hawaiian lineages*. 2013-2018 (PI; co-PIs John Harte, Rasmus Nielsen, Patrick O’Grady), $1,181,407 to UC Berkeley (collaborators in Cornell, University of Hawaii Hilo, U Maryland, Pacific Ecoinformatics, for a total award of $1,999,910). Intellectual Merit. This project aims to transform understanding of the impact of the dynamic community on biodiversity by integrating (1) evolutionary models and (2) macro-ecological theory. The synergy between the two approaches is made possible through the use of a habitat chronosequence, and corresponding space-for-time substitution, provided by the dynamic geomorphology of the young islands of the Hawaiian archipelago. We selected 6 plots in each of 15+ sites and are sorting thousands of arthropod specimens while creating an mtDNA barcode library and testing metabarcoding approaches. From these data we are estimating macroecological metrics and conducting food web analysis. For focal lineages, genomic data is providing information on population differentiation over the island chronology for different trophic groups. Broader Impacts. new species are being discovered and research is integrated into education; trained 7 postdocs, 10 graduate students, 14 undergraduates, and one high school student in the last year and gave > 11 presentations at scientific meetings. Papers to date ([Gillespie 2013](#_ENREF_6); [Brewer *et al.* 2014](#_ENREF_3); [Gillespie & Roderick 2014](#_ENREF_8); [Yim *et al.* 2014](#_ENREF_26); [Brewer *et al.* 2015](#_ENREF_2); [Warren *et al.* 2015](#_ENREF_24); [Gillespie 2016](#_ENREF_7); [Krehenwinkel *et al.* 2016](#_ENREF_13); [Rominger *et al.* 2016](#_ENREF_17); [Shaw & Gillespie 2016](#_ENREF_19)).

**Gruner**: DEB-1020007 *Collaborative Research: Interactive effects of predation and ecosystem size on arthropod food webs in Hawaiian forests fragmented by lava flows*. 2010-2015 (collaborative PIs Tad Fukami, David Flaspohler, Christian Giardina), $329,949 to U Maryland (collaborators at Stanford, Michigan Tech, and US Forest Service, for a total award of $1,213,843). Intellectual Merit. This project examined forest food webs in naturally fragmented landscapes on Hawaii Island over a 100-fold ecosystem size gradient. Our overarching objective was to test the contingent effects of an invasive omnivore, the black rat *Rattus rattus*, on bird population dynamics, arthropod food webs, and ecosystem processes. By eliminating rats from fragments up to 12 ha in size in a 4-yr press experiment, and independently excluding birds from tree canopies, we provided evidence for non-consumptive effects of rats in altering bird foraging behavior and their impacts on arthropods. This work has produced seven peer-reviewed papers ([Massol *et al.* 2011](#_ENREF_14); [Vaughn *et al.* 2013](#_ENREF_21); [Knowlton *et al.* 2014](#_ENREF_10); [Vaughn *et al.* 2014](#_ENREF_22); [Vaughn *et al.* 2015](#_ENREF_23); [Knowlton *et al.* 2016](#_ENREF_11); [Vannette *et al.* 2016](#_ENREF_20)) (), with three more in review or in revision ([Kaye 2011](#_ENREF_9); [Kovach 2012](#_ENREF_12); [Barney *et al.* In prep. Broader Impacts. More than 25 undergraduate students participated as interns and paid assistants in this research. Two students were mentored through the Pacific Internship Programs for Exploring Science (PIPES) program, which is committed to recruiting and retaining local Hawaiian students in research. Three students completed MS degrees at University of Hawaii Hilo {Phifer, 2012 #25](#_ENREF_1); [Mueller *et al.* In review](#_ENREF_15); [Wilson Rankin *et al.* In review](#_ENREF_25)), one PhD project is ongoing at Stanford University, and three postdocs were mentored and placed in subsequent positions. The project was featured in volume 16 (2012) of the *Natural Inquirer*, a middle school science education journal produced by the US Forest Service.

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