Title: Garden isles or ghost forests: disease-driven death of the dominant tree in native Hawaiian forests.

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2 pages total (assume single spaced) INCLUDING budget:

Where green leafy trees stood, imagine just bare grey branches and visible trunks; imagine the birds and insects that used to live in those trees, now gone. This has happened in forest patches throughout Northern California, as the tree disease Sudden Oak Death has killed oak trees, changing which trees thrive in the forest and which birds and animals a hiker is likely to see in the forest ().

Imagine the same scenario, magnified, on the islands of Hawaii. Rapid Ohia Death is a new disease of Hawaii’s dominant tree species, the ohia (), and it has the potential to cause extensive tree mortality, and dramatic changes in native forest vegetation and to the unique, endemic birds and insects that have co-evolved with Hawaii’s vegetation (). We are starting a research project that will investigate two questions:

1. **Can we predict the impact of Rapid Ohia Death (ROD) on tree populations?**
2. **How will the mortality of ohia affect other species?**

Question 1: Predicting disease spread and severity.– On Hawaiian islands, ohia (*Metrosideros polymorpha*) is the dominant tree, and its wide habitat range includes wet and dry forests from sea level to tree line (). Rapid Ohia Death (ROD) is caused by the fungal pathogen *Ceratocystis fimbriata*, previously a pathogen of potatoes, and has begun to cause mortality in ohia by disrupting a tree’s circulatory system (). It has affected over 6,000 acres of forest across Hawai’i island, causing 50-80% ohia mortality in patches from 1 to 100 acres ().

Our goal is to predict how the disease will spread and how extensive its effects on ohia will be. This work is important because it will identify the characteristics of ohia trees, forests, and the environment that aid disease spread. We will cooperate with the State of Hawaii, US Department of Agriculture, and US National Park Service, to share these predictions, enhancing their ability to manage the spread and mitigate the effects of ROD. We can identify risks that increase the transmission of ROD or trees susceptibility to the disease. This information may also contribute to design of disinfection protocols, allowing ohia to maintain its role in Hawaiian culture.

We will use computer simulations to predict how ROD will spread across Hawai’i. Based on our knowledge of disease ecology and forest ecology, complemented by data shared by future collaborators, we identify the characteristics of ohia (age, size, phenology, population density, insect pests) and the environment (rainfall, wind patterns, nearby tree species, human use) that determine whether a tree becomes infected, how quickly it dies, and how many other trees it can infect. We will use existing data from citizen reports, aerial surveys, and a network of long-term forest monitoring plots. Ultimately we will produce academic articles to report our findings, as well as maps and presentations for the public.

1. Introduction and Questions
   1. Hook (Problem)
      1. What would the peninsula look like without live oak trees, covered with the skeletons of recently dead ones? And the animals that depend on them
         1. Potential, with SOD
   2. Issue (Problem)
      1. Ohia is the dominant tree in Hawaii
      2. A new disease is killing ohia
   3. **Questions**
      1. Two questions our research addresses:
         1. **Question 1 – How bad will it be for trees?**
            1. **Can we predict the speed and extent of spread?**
            2. What are the impacts on trees and forests
         2. **Question 2 – How bad will it be for other species?**
            1. **How is the community responding?**

**Birds, insects**

* + - * 1. How does species loss/decline affect communities

diversity leads to… stability, productivity, services

But what follows loss of certain species…

Still an unresolved question in ecology (IMO)

1. Q1 - Disease Spread
   1. Background
      1. Ohia – dominant tree
         1. distribution
      2. Ceratocystis –
         1. A little biology
            1. Known extent and spread
            2. unknowns
         2. Other new fungal diseases that cause declines (removals)
      3. Forest changes –
         1. how much has been impacted?
   2. Significance
      1. Science
         1. Develops insight into phenomenon of emerging fungal diseases
            1. It joins several emerging fungal pathogens that have recently caused dramatic disease outbreaks, including those associated with Sudden Oak Death in northern California, bat declines across the eastern United States, and amphibian declines worldwide.
      2. Non-Science
         1. Recommendations for disinfection protocols, disease dispersal risks, responses
         2. Lay ground work for interagency cooperation
         3. Public involvement in monitoring – existing awareness and vigilance
         4. Ohia are important in culture, understanding decline and its effects…
   3. Proposed work - Phase I
      1. Mechanistic modeling to predict spread
         1. Develop model to specify parameters for which we need data
         2. Collecting existing data to parameterize: where trees infected, which individuals infected, when individuals/patches became infected, etc. Data exists in…
            1. Maps of location and onset of ROD
            2. Cooperate with federal and state agencies to get vegetation data from existing monitoring plots

Question 2: How does ohia death affect other forest species?– As the dominant tree in Hawaii’s forests, ohia feeds, houses, and has coevolved with native bird and insect species (). Secondly, ohia is the tree that colonizes new unvegetated lava, and it battles for light and water as forests age and other species take root (). Ohia is ecologically important, and as ROD kills ohia trees, the animals and plants with which it interacts will lose or gain resources. Like most trees, it has the potential to be a foundation or ‘keystone’ species that has a disproportionately large influence on the fate of the plants and animals that live in, on, or around it (). Some examples include the endangered Hawaiian honeycreepers, which drink nectar from ohia flowers, and transfer pollen. We predict that, following ROD outbreaks and death of ohia in a forest patch, birds and mobile insects will decline locally, although they may merely take up residence in intact forest. Less mobile animals, like spiders, may decline locally, but not relocate.

This work is important…

1. Q2 – Community Effects
   1. Background
      1. Some species are ‘important’
         1. But not all…
      2. Trees are important because
         1. they provide
            1. 3d structure
            2. Nutrients – leaf litter
            3. Food – tissue
            4. Other benefits
         2. Keystone / foundation species
      3. Lose foundation species, lose other species
         * 1. Arthropods
           2. Honeycreepers
   2. Significance and Impacts
      1. Addresses ecology principles
         1. Importance of species
         2. Consequences of diversity loss
      2. Information that can help agencies prioritize sensitive forest patches and species
      3. Non-Science
         1. Educational opportunities for field techs and lab students, local students
         2. Ohia are important in culture, understanding decline and its effects…
   3. Proposed work - Phase II
      1. Develop a community ‘web’ model based on literature that can be used to make predictions.
         1. Specify clear hypotheses:
            1. species dependent on ohia will decline locally, in patches

vegetation shift

small arthropods will have numerical responses, with increases in those that depend on invading plants and declines in ohia dependent species

mobile species – honeycreepers – will respond behaviorally and move to areas where resources remain, in the short term

* + 1. Use model to locate “before” sites that are likely to become infected in next 1-2 years
       1. Controls are areas that could become infected farther into future
       2. Describe ohia and other vegetation at “before” sites
       3. Describe terrestrial arthropods and birds at “before” sites.
    2. Locate die-off sites or “after” sites,
       1. describe ohia, vegetation, arthropods at “after” sites
    3. Compare communities at before and after sites
  1. Proposed work - Phase III
     1. Compare our community data to the web model to evaluate its performance, adjust model
     2. Integrate the spread and the community response model to create a ‘devastation’ model

1. Conclusion
   1. Opportunity
      1. Natural experiment – a manipulation at a scale that could not be created by researchers
      2. Disease as a ‘press’ disturbance, tree loss as a press disturbance
      3. Species loss is hard to isolate –
         1. disease outbreaks simulate single, non-random species removals
      4. BACI – need before, before its unavailable.
   2. Significance
      1. Reflect the hook:
      2. Previous ohia dieback, SOD

Budget (part of 2 pages)

1. Hellman fund: <$40,000 for 2016-2017 academic year
2. Budget justification
   1. First year of the study,
   2. Travel and preliminary field work to address question 2
3. Field tech
   1. Pay
   2. Travel
   3. Housing
4. PI
   1. Travel
   2. Housing
5. Stuff
   1. Multiple sets of field gear for infected/uninfected
   2. Disinfectants
      1. Virkon, Quat (does anyone do this yet?)
      2. What was used for SOD?
   3. Tools for measuring trees
      1. % cover thingees
      2. Leaf litter collectors (sheets, baskets)
      3. Measuring tapes
      4. Mini satellites – Erin, can Ryan give us one?
   4. Invertebrate tools
      1. Various traps
      2. Tree gassing equipment
      3. Sample bottles/whirlpaks, ethanol
   5. Bird tools
      1. Binoculars