GARDEN ISLES OR GHOST FORESTS: EFFECTS OF DISEASE-DRIVEN DEATH OF THE DOMINANT TREE ON HAWAIIAN FORESTS.

On your next forest walk, imagine yourself among grey tree trunks and bare branches instead of under shady, green, leafy masses; imagine the silence without the birds and insects that depend on those trees. You can experience this throughout northern California where the tree disease Sudden Oak Death has killed trees and has changed which trees thrive in the forest and which birds and animals you see in the forest (*1*, *2*).

Imagine the same scenario magnified across the Hawaiian islands. There, native forests are tropical gardens of unique plants, birds, and insects that evolved under the canopy of the dominant tree, the ohia. Those forests are threatened by Rapid Ohia Death (ROD), a new disease that can kill ohia and has the potential to cause extensive tree mortality across the islands (*3*), which will affect the plants and animals in Hawaii’s forests. Our research asks ***1) How will Rapid Ohia Death spread among ohia individuals and populations?*** *and* ***2) How will the subsequent death of ohia affect other forest species?***

*Predicting disease spread*.—On Hawaiian islands, ohia (*Metrosideros polymorpha*) occurs in high numbers throughout wet and dry forests from sea level to tree line (*4*, *5*). Rapid Ohia Death (ROD) is caused by the fungal pathogen *Ceratocystis fimbriata*, a pathogen of potatoes that has begun to cause mortality in ohia by disrupting trees’ circulatory systems (*3*). The disease can kill over half (possibly as high as 90%) of trees in forest patches as large as 100 acres; it has affected 6,000 – 30,000 acres of forest across the island of Hawai’i (*6*, *7*). The disease continues to spread, but biologists remain uncertain where it will spread and how many trees it will infect and kill.

Our work to predict disease spread will identify the characteristics of ohia trees, forests, and the environment that encourage the disease to spread. We can identify risk-factors that tree susceptibility to the disease and those that increase transmission of ROD. This information may help managers and policy makers design effective and minimally inhibiting disinfection protocols or quarantines for forest users. By sharing our predictions with the State of Hawaii, US Department of Agriculture, and US National Park Service, we may help stem the spread of ROD and mitigate its effects on forests.

We will use computer simulations to predict how ROD will spread across the island of Hawai’i. We will combine our experience in disease and forest ecology with data shared by future collaborators to identify characteristics of ohia (like size, hydration, proximity to other ohia) and the environment (rainfall, soil type, nearby trees) that determine whether a tree becomes infected, how quickly it dies, and how many other trees it can infect. We will use existing and future data from citizen reports, aerial surveys, and a network of long-term forest research plots.

*Measuring effects on other species.—*Ohia is the tree that first takes hold on bare lava rock (*8*), and as the forest develops, it feeds and shelters native plants, birds and insects that have coevolved with it (*9*, *10*). As ROD kills ohia trees, plants and animals that depend on ohia will lose a resource, while other plants respond by taking advantage of shade free space and unabsorbed soil water (*4*) and will provide for a new set of birds and insects. Because of its ecological importance, the loss of ohia may have disproportionately large consequences for the community. We intend to measure those consequences.

As the world’s biodiversity declines, consequences include the loss of products and services that benefit humans. For example, ohia provide flowers used in Hawaiian traditions (*11*), and they help soil and vegetation develop on exposed lava (*4*, *8*). We can expect these benefits to decline with ohia. By describing and predicting how ROD affects forest communities, we can help Hawaii’s resource managers protect areas where ohia declines would have especially severe impacts on ecosystem services and on already threatened plants and animals.

This disease outbreak presents a rare opportunity for us to study the ecological effects of declining biodiversity using a valuable approach: in killing only ohia, the disease effectively creates an experiment in which a single species is removed from a community. For ecologists, this is akin to removing a single brick in a wall, and seeing how the other bricks – other forest species – fall or stay put, which allows us to measure whether that one brick – ohia – is a “keystone” upon which the entire community depends (*12*). As we continue to face biodiversity loss, studies like this help us generalize the effects of species’ declines.

Our initial identification of ROD susceptible forest patches will allow us to select sites for this naturally occurring experiment. Before and after ROD outbreaks, we will work with local biologists to identify and count the plants and animals that we find in these patches. The before and after comparison, and the size of the difference, will tell us how the level to which ohia is a keystone species in Hawaii forests.

*Conclusion.—* As we measure how ROD spreads and affects Hawaiian forest communities, we can provide information to aid forest protection and conserve plants and animals that depend on ohia. We see this disease outbreak as an opportunity to study the importance of species and the consequences of biodiversity loss. This research is urgent and timely, because continued loss of healthy forests eventually reduces our ability to rigorously compare them to diseased forests. Once surrounded by the ghostly grey, leafless trunks of the trees that support Hawaii’s island gardens, it may be too late to ask “Why are ohia important?”

Budget:

|  |  |  |
| --- | --- | --- |
|  | Item | Cost |
|  | Field technician wages: $\_\_.00 / hour x \_\_\_hours |  |
|  | PI travel: Airfare @ $600.00 + hotel @ $100.00 / night x 14 nights | 2000.00 |
|  | Equipment: |  |
|  | Disinfectant: Bleach @ $100 / 12 gallons  Disposable gloves:  Rubber boots: 2 pairs x 2 people @ $20.00 each  Tree measuring equipment:  Densiometer: 2 @ $100.00 each  Meter tapes: 2 @ $30.00 each  Insect trapping equipment:  Malaise traps: 4 @ $250.00  Sticky traps: 100 @ $0.40 each  Whirl paks: $50.00  Ethanol: 5 gallons @ $40.00 each  Bird tools: binoculars @ $100.00 | 100.00  80.00  200.00  60.00  1000.00  40.00  50.00  200.00  100.00 |
|  | Overhead? |  |
|  | Total |  |

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