**NASA DEVELOP National Program**

**2019 Summer Project Proposal**

**Colorado – Fort Collins**

**Moloka’i Water Resources**

*Mapping the Iimpacts of Non-native Rust Disease on Ōhiʻa Trees and Sediment Runoff on Moloka’i Using Earth Observations*

**Project Overview**

***Project Synopsis*:** This project will use Landsat and Sentinel imagery to provide partners with maps of 1) the impacts of a non-native rust disease (*Puccinia psidii*) on native ōhiʻa trees (*Metrosideros polymorpha)* and 2) coastal turbidity during and after the 2017 Puccinia rust outbreak on Moloka’i. The team will utilize several spectral algorithms and modeling techniques to create impact maps as well as written tutorials outlining a repeatable methodology for future analyses. These end products will be used by partners from The Nature Conservancy (TNC) and USGS to understand the scope of the problem and guide restoration efforts of ōhiʻa populations.

***Community Concern:*** Hawaii is home to a bounty of diverse flora and fauna. The native ōhiʻa tree is a particularly iconic and culturally important native species, providing crucial ecosystem services and aesthetic beauty. However, due to an outbreak of Puccinia rust on the island of Moloka’i in 2017, this species experienced widespread defoliation and mortality. Changes to watershed dynamics stemming from the rust disease’s impacts have been observed. Forest overstory loss from the *Puccina* rust can lead to an increase in runoff and erosion, resulting in higher turbidity in coastal waters. Partners at the Nature Conservancy and USGS are interested in using ōhiʻa defoliation maps along with turbidity maps to better inform their management and restoration efforts. Particularly, they are interested in comparing rust disease impacts inside and outside of fenced exclosures designed to exclude invasive deer and feral pigs. They have observed reduced rust impacts inside exclosures, but lack the data to test this observation.

***Source of Project Idea:*** Dr. Paul Evangelista, the CO science advisor, introduced Rudi Hunke, Dr. Helen Soafer, and Stephanie Dunbar to the CO Center Lead. This proposal capitalizes on the strengths of project partners at The Nature Conservancy, USGS, and Puu O Hoku Ranch while leveraging the geospatial capacity of the Colorado – Fort Collins DEVELOP node.

***National Application Area Addressed:*** Water Resources

***Study Location:*** Molokai, HI

***Study Period:*** 2016 – 2018(March – October)

***Advisors:*** Dr. Paul Evangelista (Colorado State University, Natural Resource Ecology Laboratory), Dr.

Catherine Jarnevich, (USGS, Fort Collins Science Center), Nicholas Young (Colorado State University,

Natural Resource Ecology Laboratory), Tony Vorster (Colorado State University, Natural Resource Ecology

Laboratory)

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **The Nature Conservancy** | Stephanie Dunbar, Project Manager | End User | No |
| **USGS, Fort Collins Science Center**  | Dr. Helen Soafer, Ecologist | End User | Yes |
| **Pu’u O Hoku Ranch** | Rudi Hunke, Pu’u O Hoku Ranch Manager | Collaborator | No |

***End-User Overview***

***End User’s Current Decision-Making Process:*** One of the main goals of The Nature Conservancy is to conserve biodiversity, so they are interested in better understanding ōhiʻa defoliation and mortality in 2017 as well as quantifying the effects of their fenced exclosures. They would also like to know the impact of increased runoff from the defoliation and mortality on coastal water turbidity. Currently, TNC has limited ōhiʻa occurrence and impact point data and lacks water quality monitoring data. The organization has limited capabilities for applying geospatial and spectral modeling techniques using NASA Earth observations. The USGS has a particular interest in the management of invasive species and, while they have geospatial expertise within the agency, they have not had the resources to focus on mapping rust disease impacts on Molokai to date.

***End User’s Capacity to Use NASA Earth Observations:***

*The Nature Conservancy –* The employees at the TNC in Hawaii have limited spatial analysis capabilities but they have employed geospatial products derived from NASA Earth observations to inform management decisions to address other concerns. This project will increase their understanding of the capabilities of incorporating NASA Earth observations into future management decisions.

*USGS, Fort Collins Science Center* – The point of contact has spatial analysis experience with habitat suitability modeling and some familiarity using NASA Earth observations in their research, but has limited experience with detection modeling, especially in the context of pest impact mapping. This project will further build the Fort Collins Science Center’s capacity for monitoring tree defoliation and mortality due to invasive pests and will expose the organization to new technologies that they may use to discover and analyze NASA Earth observations (e.g., Google Earth Engine).

***Collaborator Overview***

***Collaborator Support:***

*Pu’u O Hoku Ranch* – The managers at this organization will provide *in situ* field validation data, community context, and local knowledge to help the teams model and validate ōhiʻa rust impact maps.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** The team will communicate with partners and collaborators biweekly

via teleconference meetings. The Center Lead and Project Lead will be the primary points of contact with the partner organizations.

***Transition Plan*:** At the end of the term, the team will host a web-based seminar to disseminate project results. A handoff package will be sent to the end users via email.

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 8 OLI** | Surface reflectance, normalized difference vegetation index (NDVI), normalized difference moisture index (NDMI), normalized difference turbidity index (NDTI), tasseled cap brightness, greenness, and wetness | This dataset will provide the temporal (16 days) and spatial (30 m2) resolution needed to derive environmental predictive variables for modeling and calculate turbidity using algorithms. |
| **Sentinel-1 C-SAR** | Synthetic Aperture Radar backscatter values, surface roughness | This dataset will provide high temporal resolution (6 days) imagery used to refine tree mortality modeling. |
| **Sentinel-2 MSI** | Surface reflectance, NDVI, NDMI, NDTI | This dataset will provide the spatial (10-60 m2) resolution needed to derive environmental predictive variables for modeling and calculate turbidity using algorithms. |
| **SRTM** | Elevation, slope, aspect, compound topographic index | This dataset will be used to derive topographic indices to use as predictors representing important characteristics of ōhiʻa habitat. |

***Ancillary Datasets:***

North American Land Data Assimilation System (NLDAS-2) Mosaic Precipitation, Soils, Surface Water –

 Environmental Predictor Variables Data for Modeling

Puu O Hoku Ranch – Partner *in-situ* data for validation

USGS National Land Cover Database (NLCD) – Environmental Predictor Variables Data for Modeling

LANDFIRE Existing Vegetation Type – Raster data showing forest type distributions for determining ōhiʻa and rose apple distribution

Native ōhiʻa shapefile – Shapefile from The Nature Conservancy showing the distribution of ōhiʻa in our study area

Locations of fenced exclosures – Polygon data provided by the Nature Conservancy

***Modeling:***

Random Forest (RF) (POC: Dr. Catherine Jarnevich, USGS Fort Collins Science Center)

***Software & Scripting:***

Esri ArcGIS – Image processing and end product generation

R – Statistical analyses and raster processing

Google Earth Engine API – Large-scale image analysis

ACOLITE – Image processing

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **Maps of ōhiʻa Rust Impact from 2015 to 2019** | Maps will elucidate ōhiʻa rust impacts across time on the island of Molokai to identify the scope of the problem and guide future monitoring and conservation efforts by partners. | Random Forest models will be trained with field survey data and indices created from SRTM, Sentinel, and Landsat to create ōhiʻa rust impact and maps from 2015 to 2019. | N/A |
| **Maps of Turbidity**  | Maps will inform partners about coastal turbidity after ōhiʻa defoliation events. | Turbidity algorithms will be applied to Landsat 8, and Sentinel-2 imagery to create turbidity maps. | N/A |

***End-User Benefit*:** This project will inform The Nature Conservancy on how their restoration efforts, e.g. exclosures, impact forest recovery. It will also help them better understand the connection between o’hia forest health and water quality. The project will also support the USGS in their monitoring and detection of invasive species. End products will be integrated into both The Nature Conservancy and USGS’s decision making, environmental monitoring, and conservation processes.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 1 Term: 2019 Summer

***Related DEVELOP Work:***

2018 Fall (CO) – Colorado & New Mexico Disasters: Using NASA Earth Observations to Quantify Tree Mortality and Burn Severity to Inform Management on Ranches and Open Lands

2017 Fall (CO) – Intermountain West Ecological Forecasting: Utilizing NASA Earth Observations to Forecast Forest Risk to Bark Beetle Attack in Support of a Forest Bioenergy Feasibility Assessment

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