**NASA DEVELOP National Program**

**2020 Fall Project Proposal**

**Colorado – Fort Collins**

**California & Oregon Ecological Forecasting**

*Forecasting Suitable Habitats for Coast Redwood (Sequoia sempervirens) Migration for Conservation and Restoration Planning*

**Project Overview**

***Project Synopsis*:** This project will map current and future suitability for seedling establishment and natural migration of coast redwood (*Sequoia sempervirens*) using species-specific environmental predictor variables created by the DEVELOP team. Partnering with Save the Redwoods League (STRL), the team will utilize Landsat satellites to reconstruct a disturbance history and will generate current and future fog indices, an important source of moisture and nutrients, utilizing derived data from the GOES satellites. By combining these products, the team will determine how habitat suitability for seedling establishment of coast redwood may shift or expand under projected climate change. This will aid the organization in evaluating the potential for northern range expansion and support broader scale conservation planning.

***Community Concern:*** Coast redwood, the tallest tree species in the world, is currently distributed along a narrow strip of coastline stretching from Curry County, Oregon to Monterey County, California. While only a fraction of the species old-growth forests remain, second- and third-growth forests are actively being conserved and restored, and new conservation opportunities remain to be actively sought. Recent research has pointed towards the potential for expanding climatic suitability of coast redwood at its northern range margin, but species-specific predictors of environmental suitability, such as the current and future distribution of fog, an important source of moisture and nutrients, and magnitude and extent of recent disturbances, are not currently available or included in these analyses and projections. By creating species-specific environmental predictors, this project will help to delimit new areas at the species’ northern range margin that are the most environmentally suitable for current and future seedling establishment.

***Source of Project Idea:*** In April 2020, mentors and science advisors from the Colorado – Fort Collins node held a teleconference with Save the Redwood’s League to discuss the NASA DEVELOP Program and potential partnerships. This project idea was formed in these discussions.

***National Application Area Addressed:*** Ecological Forecasting

***Study Location:*** Southwest OR and northern CA

***Study Period:*** 1984 – 2020; Forecasting to 2050 & 2100

***Advisors:*** Dr. Paul Evangelista (Colorado State University, Natural Resource Ecology Laboratory), Dr. Catherine Jarnevich (USGS, Fort Collins Science Center), Dr. Anthony Vorster (Colorado State University, Natural Resource Ecology Laboratory), Brian Woodward, M.S. (Colorado State University, Natural Resource Ecology Laboratory), Nicholas Young (Colorado State University, Natural Resource Ecology Laboratory)

**Partner Overview**

***Partner Organization:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Save The Redwoods League** | Dr. Kristen Shive, Director of Science | End User | No |

***End User Overview***

***End User’s Current Decision-Making Process:***

Save the Redwoods League is the primary non-profit conservation organization tasked with the protection, conservation, and restoration of coast redwood forests of California and southwestern Oregon. The organization accomplishes this mission by “purchasing redwood forests, regenerating logged forests so they become spectacular havens for future generations, studying how to best protect and restore these global treasures, and introducing people to these magical places.” The organization utilizes intensively collected field data and a variety of geospatial information, including satellite imagery and LiDAR, to support their current decision making processes.

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

*Save the Redwoods League* – This organization is familiar with NASA Earth observations, however it has not used them to help to determine current and future habitat suitability at range-wide scales. This project will create a robust, replicable methodology that will build the organization’s capacity to monitor how climate change and historical, ongoing, and future disturbances may alter habitat suitability for natural species migration.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** The team will communicate with partners at STRL through web conferences biweekly throughout the term. The project mentors, Fellow and Project Lead of this project will be the primary points of contact with the partner organization.

***Transition Plan*:** At the end of the term, the team will host a virtual webinar-based seminar to disseminate project results to interested members of the public and the STRL staff. All end products and reports will be provided digitally to STRL staff.

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **Landsat 5 TM** | Spectral vegetation indices | Spectral vegetation indices from the Landsat satellites will be utilized in the LandTrendr model to reconstruct a disturbance history from 1984-2020 for northern California and southern Oregon. |
| **Landsat 7 ETM+** | Spectral vegetation indices |
| **Landsat 8 OLI** | Spectral vegetation indices |
| **GOES-16** | Fog and low-cloud indices | This derived dataset will be used to create current and future fog hours per day under projected climate change scenarios for California and Oregon. |

***Ancillary Datasets:***

* University of California Davis, WorldClim current and future climatic variables – Environmental indices for current and future habitat suitability modeling

***Modeling:***

* Random forests (RF), (POC: Anthony Vorster, Colorado State University) – Future fog hour projections and indices creation
* Maxent v3.4 (POC: Paul Evangelista, Colorado State University) – Current and future environmental suitability modeling
* LandTrendr (POC: Justin Braaten, Oregon State University) – Historical disturbance detection and mapping

***Software & Scripting:***

* Software for Assisted Habitat Modeling (SAHM) – Modeling execution and documentation
* ESRI ArcGIS – Image processing, end product and map generation
* R – Modeling execution, statistical analyses, raster processing
* Google Earth Engine – Image processing and LandTrendr model execution

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **Forest Disturbance History, 1984 - 2020** | Disturbed areas such as harvest and fire are thought to be highly suitable for establishment of coast redwood seedlings. | A time series from Landsat 5, 7, & 8 will be utilized in the LandTrendr model to delineate and map historical disturbance events. | N/A |
| **Current (2020) and Future (2050 and 2100) Fog Indices** | Fog is thought to be a climatic constraint on the distribution of coast redwood. These products will be utilized to determine how the presence and intensity of fog could change under multiple scenarios of global climatic change utilizing simplistic climatic variables as a proxy for a complex climatological process. | A current GOES-derived fog dataset exists for a small portion of California. These data will be combined with current and future climatic data to model current and future fog hours for California and Oregon. | N/A |
| **Current (2020) and Future (2050 and 2100) Coast Redwood Habitat Suitability Models** | Fog indices will be integrated with standard climatological variables derived from WorldClim to project current and future suitability for seedling establishment. | Fog and disturbance variables will be created and integrated with WorldClim variables in a MaxEnt habitat suitability model and projected into future projected climatic space. | N/A |
| **Overlay Analysis** | Overlay of current climatic suitability, future climatic suitability, and disturbance maps to target areas particularly suitable for natural establishment of redwood and areas to field sample to locate natural range expansion. | Each of the above end-products will be integrated into a single habitat suitability overlap analysis and map. | N/A |

***End User Benefit*:** This project will increase understanding of the potential for a northern range expansion of coast redwood (*Sequoia sempervirens*) under climate change. Project partners have requested habitat suitability projections to prioritize their conservation work, which includes property acquisition, restoration work, and research to protect and restore redwood forests. This work can inform where conservation and restoration activities and resources should be targeted, considering the many uncertainties about how changing climatic conditions will impact Pacific Northwest forest communities.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 1 Term: Fall 2020

***Related DEVELOP Work:***

2019 Spring (CO) – Nevada & Oregon Ecological Forecasting: Employing NASA Earth Observations to Create Enhanced Bare Ground Layers for Invasive Species Habitat Suitability Modeling

**References:**

Fernández, M., Hamilton, H. H., & Kueppers, L. M. (2015). Back to the future: using historical climate variation to project near‐term shifts in habitat suitable for coast redwood. *Global Change Biology, 21*(11), 4141-4152.

DellaSala, D. A., Brandt, P., Koopman, M., Leonard, J., Meisch, C., Herzog, P., ... & von Wehrden, H. (2015). Climate change may trigger broad shifts in North America's Pacific Coastal rainforests. Reference Module in Earth Systems and Environmental Sciences.

Torregrosa, A., Combs, C., & Peters, J. (2016). GOES‐derived fog and low cloud indices for coastal north and central California ecological analyses. *Earth and Space Science, 3*(2), 46-67.