**NASA DEVELOP National Program**

**2018 Spring Project Proposal**

**Maryland – Goddard**

**Kenai Peninsula Ecological Forecasting**

*Mapping Tree-line Rise and Wetland Conversion in order to Supplement Resource Management Actions in a Changing Alaskan Climate*

**Project Overview**

***Project Synopsis*:** Over the past 60 years, mean average temperatures in Alaska have increased by an average of 1.7°C**.** As a result, woody vegetation has begun to colonize wetland and alpine habitats. DEVELOP will partner with the Kenai National Wildlife Refuge (NWR) to identify areas of increasing woody vegetation on the Kenai Peninsula. The team will classify vegetation types and produce a change detection analysis of alpine and lowland wetlands that will help Kenai NWR staff understand how rates of afforestation vary across the landscape and if rates are accelerating. This will support refuge staff in decisions affecting the active management of alpine wildlife species (i.e. caribou, dall sheep, and ptarmigan) and habitats, as well as fire management strategies, such as the placement of fuel breaks, to manage wildfire in the future.

***Community Concern:*** The six-million acre Kenai Peninsula is located in south-central Alaska and straddles the ecotone between the southern extent of the boreal forest and the northwestern extent of the Pacific coastal rainforest. Two landscape-scale trajectories of afforestation have been linked to warming temperatures: (1) tree-line rise (white spruce and mountain hemlock), and (2) tree colonization of drying wetlands (black spruce). Alpine-dependent species, such as caribou and ptarmigan, are losing habitat, but it is not known if all populations are experiencing similar habitat loss. Wetland afforestation will make the black spruce forests more contiguous and change both fire regime patterns and the habitat available to wetland-associated species. Thus, NWR staff need to understand the spatial extent and distribution of vegetation change for adaptation planning.

***Source of Project Idea:*** This project is part of an August 2017 request by proposed project partner Dawn Magness, Landscape Ecologist with the US Fish and Wildlife Service at the Kenai National Wildlife Refuge.

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

***Study Location:*** Kenai Peninsula, AK

***Study Period:*** January 1985 – January 2018; Forecasting to 2050 and/or 2100

***Advisors:*** Dr. John Bolten (NASA Goddard Space Flight Center), Dr. Adrianna Foster (NASA Arctic Boreal Vulnerability Experiment, Goddard Space Flight Center)

**Partner Overview**

***Partner Organization:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **US Fish and Wildlife Service, Kenai National Wildlife Refuge** | Dawn Magness, Landscape Ecologist | End User | Yes |

***End-User Overview***

***End User’s Current Decision-Making Process:*** The end user of this project is the Kenai NWR administered by the US Fish and Wildlife Service. Currently, the refuge monitors (i.e. minimum counts, radio-tracking) alpine species, such as caribou and dall sheep, whose harvest levels are set by Alaska Fish and Game. Current game management frameworks do not consider transforming habitat conditions; therefore, population decline could lead to ineffective management strategies in the future. The refuge’s biology staff needs to understand how tree line rise is changing habitats across the landscape to make recommendations regarding harvest to the Board of Fish & Game.

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

*US Fish and Wildlife Service, Kenai National Wildlife Refuge* – Kenai NWR staff have visited the NASA Earth observations website to browse the available datasets, but have not used the data in an analysis. This project will build the capacity of Kenai NWR staff to access data for regionally-scaled change detection. Kenai NWR has calculated empirical rates of vegetation change from historical data, but has not accessed remotely-sensed data sets for more spatially-comprehensive mapping or to understand whether rates of change are accelerating. Refuge staff have GIS capabilities: the refuge maintains a geospatial database and staff use ESRI GIS software.

***Collaborator & Boundary Organization Overview***

***Dissemination by Boundary Organizations*:**

*US Fish and Wildlife Service, Kenai National Wildlife Refuge* – The Kenai NWR will share the DEVELOP project results directly with the Chugach National Forest and Kenai Fjords National Park. Alaska Fish & Game will be contacted if outputs suggest that habitat constraints may need to be considered when setting future population goals. Other land management agencies will receive information in the annual Kenai Peninsula Land Management Forum, which is used to share information to better coordinate management activities. NASA DEVELOP results will also be shared directly with partners tasked with wildlife management, such as the Kenai Peninsula Borough and the State of Alaska, such as the All Hands All Lands network. Finally, local nonprofit and other groups with an interest in climate change adaptation and planning, such as Kenai Change and Kenai Rotary, will be briefed via a presentation to their group.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** The team lead will serve as the primary point of contact for communication with the project partner. They will communicate through tri-weekly teleconferences and email updates as necessary.

***Transition Plan*:** During week 10, end-products excluding tools and scripts will be transitioned remotely during a virtual handoff to discuss results and answer any questions regarding the products. Tools and scripts will be handed off after they have gone through the NASA software released process. A tutorial for the tools will be provided.

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **Landsat 5 TM** | Multi-spectral imagery | Imagery will be used to identify historical vegetation presence at the landscape scale. |
| **Landsat 8 OLI** | Multi-spectral imagery | Imagery will be used to identify historical vegetation presence at the landscape scale. |
| **Sentinel-2 MSI** | Multi-spectral imagery | Imagery will be used to identify current vegetation presence at the landscape scale. |
| **SMAP L-band Radiometer** | Soil moisture data | Soil moisture data will be implemented to assist in wetland identification and fire risk determination. |
| **SRTM** | Elevation data | Elevation data will be used to supplement tree line rise assessments across the study area. |
| **G-LiHT** | Hyperspectral imagery, vegetation indices, spectral signatures | Hyperspectral imagery, vegetation indices, and spectral signatures will be used to aid in identifying vegetation by type for classification. |

***Ancillary Datasets:***

US Forest Service Forest Inventory and Analysis plots – classification of vegetation

Kenai National Wildlife Refuge legacy vegetation plots – classification of vegetation

Kenai National Wildlife Refuge 2004 and 2006 LTEMP plots extending the FIA sampling grid to non-forested locations within the refuge – classification of vegetation

Kenai National Wildlife Refuge fire polygons from 1708-2017 – fire history data

Kenai National Wildlife Refuge high resolution aerial photos 2016 – validation data

Alaska Department of Natural Resources forest health survey polygons 1989-2010 – identification of bark beetle infestation

***Modeling:***

TerrSet Geospatial Monitoring and Modeling System Land Change Modeler (POC: Dr. James Toledano, Clark Labs)

***Software & Scripting:***

Google Earth Engine API – acquisition, mapping, classification of Landsat, SMAP, & SRTM data

Esri ArcGIS 10.4.1 – raster manipulation and analysis, map creation

Exelis ENVI 5.3 – raster manipulation and analysis

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **Kenai Peninsula Land/Vegetation Change Detection Maps** | A suite of static visualizations showing empirical rates of land cover change between multiple time steps will help the partner efficiently direct management efforts on the Kenai Peninsula. | Classification and change detection using multi-spectral imagery and vegetation indices derived from Landsat 5 TM, Landsat 8 OLI, Sentinel-2 MSI, and hyperspectral imagery from G-LiHT. | I |
| **Kenai Peninsula Land/Vegetation Forecast Maps** | A suite of static visualizations forecasting empirical rates of land cover change based on historical trends will help the partner efficiently direct management efforts on the Kenai Peninsula. | Susceptibility mapping with the suite of sensors (Landsat 5 TM, Landsat 8 OLI, Sentinel-2 MSI, and G-LiHT) will be combined with ancillary data via classification and regression trees. | I |
| **Kenai Peninsula Land/Vegetation Change Detection Script** | This product will include the script required to replicate land/vegetation change detection mapping in Google Earth Engine. | Change detection using imagery, vegetation indices, and classifications derived from Landsat 5 TM, Landsat 8 OLI, Sentinel-2 MSI, and G-LiHT | III |

***End-User Benefit*:** The change detection map and future forecast will allow Kenai NWR biology staff the ability to design future research on the impacts of afforestation on wildlife species and ecological processes. The forecasting maps will be used to visualize and communicate potential future habitat conditions to agencies responsible for managing fish and wildlife populations. Without information about the spatial extent and distribution of change, Kenai NWR staff may not be able to develop representative studies for the Kenai Peninsula. The map products will also be useful for beginning a dialog about future environmental impacts and to help land managers and local communities to refocus management expectations. For example, sheep harvest levels may change in the future and the Kenai NWR staff will need to start a dialog with communities and other management agencies about what lower harvests may mean for the region.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 1 Term: 2018 Spring

***Related DEVELOP Work:***

2017 Summer (GSFC) – Chesapeake Bay Ecological Forecasting: Utilizing NASA Earth Observations to Monitor Marsh Health in the Chesapeake Bay to Support the Maryland Department of Natural Resources Coastal Resiliency Assessment

2015 Spring (LaRC) – Great Lakes Climate: Impact of Decreasing Lake Water Levels on Great Lakes Wetlands

2014 Fall (LaRC) – Monitoring the Impacts of Climate Change and Decreasing Water Levels on Wetlands in the Great Lakes Region of North America

2013 Spring (MSFC) – Utilizing NASA Earth Observations to Analyze Wetland Gain and Loss in Threatened Wetland Areas in South Carolina

**Notes & References:**

***References:***

Anderson, H.E. (2009). Using airborne light detection and ranging (LIDAR) to characterize forest stand condition on the Kenai Peninsula of Alaska. *Western Journal of Applied Forestry*, *24*(2), 95-102.

Berg, E.E., McDonnell Hillman, K., Dial, R.., & DeRuwe, A. (2009). Recent woody invasion of wetlands on the Kenai Peninsula Lowlands, south-central Alaska: A major regime shift after 18,000 years of wet *Sphagnum-*sedge peat recruitment. *Canadian Journal of Forest Research, 39*(11), 2033-2046. <https://doi.org/10.1139/X09-121>

Berg, E. (2005, September 16). Refuge Notebook: Shrub invasion shows recent drying of ancient Kenai peatlands. *Peninsula Clarion*. Retrieved from <https://www.fws.gov/uploadedFiles/Region_7/NWRS/Zone_2/Kenai/Sections/What_We_Do/In_The_Community/Refuge_Notebooks/2005_Articles/Refuge_Notebook_v7_n35.pdf>

Dial, R.. and Berg, E. (2007, June 1). Refuge Notebook: Kenai Mountain treeline advances like spreading bread mold, not like rising bathtub water. *Peninsula Clarion*. Retrieved from <https://www.fws.gov/uploadedFiles/Region_7/NWRS/Zone_2/Kenai/Sections/What_We_Do/In_The_Community/Refuge_Notebooks/2007_Articles/Refuge_Notebook_v9_n19.pdf>

Dial, R. J., Berg, E. E., Timm, K., McMahon, A., & Geck, J. (2007). Changes in the alpine forest-tundra ecotone commensurate with recent warming in Southcentral Alaska: Evidence from orthophotos and field plots. *Journal of Geophysical Research*: *Biogeosciences, 112*(G4), doi:[10.1029/2007JG000453](file:///C%3A%5C%5CUsers%5C%5CSara%5C%5CDownloads%5C%5C10.1029%5C%5C2007JG000453).

Dial, R. J., T. S. Smeltz, P. F. Sullivan, C. L. Rinas, Timm, K., Geck, J. E., Tobin, S. C., Golden,T. S., & Berg, E. C. (2016). Shrubline but not treeline advance matches climate velocity in montane ecosystems of South-central Alaska. *Global Change Biology,* *22*(5), 1841–56.

Klein, E., Berg, E.E., & Dial, R. (2005). Wetland drying and succession across the Kenai Peninsula Lowlands, South-central Alaska. *Canadian Journal of Forest Research, 35*(8), 1931-1941. <https://doi.org/10.1139/x05-129>

Olson, N. (2013, November 22). Refuge Notebook: Dall Sheep in a Changing World. *Peninsula Clarion.*  Retrieved from <https://www.fws.gov/refuge/Kenai/community/2013_article/11222013.html>