**NASA DEVELOP National Program**

**Maryland** – **Goddard**

*Project Summary – Summer 2018*

**Kenai Peninsula Disasters**

*Evaluating Grassland Conversion and the Related Likelihood of Fire Disturbance to Enhance Fire Monitoring and Management in the Kenai Peninsula, Alaska*

**VPS Title:** The Beetles’ Greatest Hits: Grassland Conversion and Fire Risk on the Kenai Peninsula

**Project Team**

***Project Team*:**

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**Project Overview**

***Project Synopsis*:** On Alaska’s Kenai Peninsula, the conversion of spruce forest to grassland heightens wildfire potential. Extensive damage from a spruce beetle infestation in the 1990’s contributes to the region’s fire risk, as spruce canopy loss permits further grassland advancement and generates dry surface fuel. NASA Earth observation imagery allowed us to classify Kenai’s surface cover at multi-year intervals to quantify and assess patterns in grassland conversion and change over time. With this information, as well as data on factors like temperature and topography, we were able to create a map of wildfire risk to support decision-making in Kenai’s wilderness management community.

***Abstract*:**

Spruce beetle-induced (*Dendroctonus rufipennis* (Kirby)) mortality on the Kenai Peninsula has heightened local wildfire risk as canopy loss facilitates the conversion from blank to fire-prone grassland. We collected images from NASA Earth observations to visualize land cover succession at roughly five-year intervals following a severe, mid-1990’s beetle infestation to the present. Using ArcGIS Pro, we classified these data by vegetation cover type to quantify grassland encroachment patterns over time. We used the raster calculator in ArcGIS Pro to conduct a change detection analysis on the land cover classifications. The resulting change image will give the Kenai National Wildlife Refuge (KENWR) ecologists a better understanding of where forests have converted to grassland since the 1990s. These classifications provided a foundation for us to integrate digital elevation models (DEMs) and geospatial temperature and precipitation data into a model using R for assessing and mapping changes in wildfire risk. Spatial representations of this risk will contribute to a better understanding of ecological trajectories of beetle-affected landscapes, thereby informing management decisions at KENWR.

**Keywords:**

Remote sensing, Landsat, grassland, fire susceptibility, land cover, spruce forest, habitat conversion

***National Application Area Addressed:*** Disasters

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

***Study Period:*** 1989-2017

***Community Concern:***

* In the late 1990s, an extensive spruce beetle (*Dendroctonus rufipennis)* outbreak across Alaska triggered large-scale mortality of white (*Picea glauca*) and Lutz spruce (*Picea x lutzii*). The impacts of these outbreaks include habitat loss, depletion of a key economic resource, aesthetic damages, and an increased risk of property damage due to treefall events.
* Later stages of beetle-induced tree spruce mortality exhibit foliage desiccation (“red phase”) and eventual needledrop (“gray phase”). This results in an accumulation of dry surface fuels as well an opening of the forest canopy, which has been observed on the Kenai Peninsula to allow the introduction of fire-prone bluejoint grasses. This is exacerbated by the observed trend of rising temperatures and wetland drying in the region, contributing to increased risk of springtime fires in the wake of beetle outbreaks.
* Fire control in the area is expected to be especially difficult and dangerous, as beetle damage to large trees can increase heat output and the likelihood of uprooting or trunk collapse.
* Local wilderness management personnel are invested in better understanding the ecological trajectory of these grasslands to aid in making long-term management decisions.

***Project Objectives:***

* Map and quantify the forest-to-grassland conversion from 1989-2017
* Evaluate and map fire susceptibility factors of new grasslands, including topography and temperature

**Partner Overview**

***Partner Organization:***

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

***Decision Making Practices & Policies***:

The Kenai National Wildlife Refuge (KENWR) has a legislative mandate under the Refuge System Improvement Act to maintain the biological integrity, diversity, and health of the ecosystems they manage. Biological surveys, such as the Long Term Ecological Monitoring Program (LTEMP), are conducted in concert with the US Forest Service (USFS) Forest Inventory and Analysis (FIA) National Program plots to monitor the abundance and stability of species and habitat. The KENWR seeks to adapt their management strategies for changing fire regimes after the widespread conversion from forest to grassland following a series of bark beetle infestations. The refuge currently engages in fire management activities to allow wildfires to occur while protecting the urban interface and local communities. The staff are considering tree plantings and are beginning common-garden experiments to understand which tree species will be viable. They are also conducting baseline inventories of biological diversity in grass-dominated areas. The refuge has not applied remote sensing methodologies to identify deforested areas with the grass biomass needed to carry litter fires in the spring.

***Project Benefit to End User***:

We will provide the KENWR with maps of the Kenai Peninsula showing where spruce forests have converted to grassland. This change detection map will allow the refuge ecologists to determine if the grasslands are a new ecological trajectory in the region or a delayed ecological succession, which will eventually return to forest. Based on the results, refuge staff may decide to engage in active management such as tree planting and fuel reduction, to facilitate reforestation and reduce fire risk, or they may decide to embrace the grassland with prescribed spring fires and the introduction of functional grazers. We will also create a fire risk map of the new grasslands, which the ecologists can use to better understand the changing fire regime and inform their fire management decisions.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **Landsat 4 TM** | Spectral vegetation indices | Spectral bands and vegetation indices were used to identify historical vegetation presence at the landscape scale, while aiding in tracking amounts of sudden change. |
| **Landsat 5 TM** | Spectral vegetation indices | Spectral bands and vegetation indices were used to identify historical vegetation presence at the landscape scale, while aiding in tracking amounts of sudden change. |
| **Landsat 7 ETM+** | Spectral vegetation indices | Spectral bands and vegetation indices were used to identify historical vegetation presence at the landscape scale, while aiding in tracking amounts of sudden change. |
| **Landsat 8 OLI** | Spectral vegetation indices | Spectral bands and vegetation indices were used to identify historical vegetation presence at the landscape scale, while aiding in tracking amounts of sudden change. |
| **Terra MODIS**  | Thermal Anomalies/Fire detection | Fire detection history aided in the classification of the fire risk window. |
| **Aqua MODIS**  | Thermal Anomalies/Fire detection | Fire detection history aided in the classification of the fire risk window. |

***Ancillary Datasets:***

Alaska FIREHouse Database – Historical fire polygons for identifying sites of particular interest in our change analysis

Kenai National Wildlife Refuge vegetation ground truth data – Point data from 2015 keyed to vegetation type using Viereck’s The Alaska Vegetation Classification system were used to train and validate the land cover classifier

National Geospatial-Intelligence Agency NextView – High-resolution images were used for validating the land cover classifier

Scenarios Network for Alaska and Arctic Planning (SNAP) – Resource for historical Alaskan climate data, used as an input for fire risk modeling

USGS 3D Elevation Program (3DEP) – elevation and topography data used as an input to the fire risk model

USGS LANDFIRE Reference Database (LFRDB) – vegetation classification data was used as a reference when training the land cover classifier

***Software & Scripting:***

R 3.4.3 – Data processing, statistical analyses, and figure generation

Esri ArcGIS Pro 2.2 – Raster manipulation and analysis, land cover classification of imagery, and map creation

QGIS 2.18 – Raster manipulation and analysis, and map creation

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Earth Observations Used**  | **Partner Benefit & Use** | **Software Release Category** |
| **Land Cover Classification/ Grass Cover Detection Map** | Landsat 5 TM,Landsat 8 OLI | This product will help the partner determine areas at risk of fire and measure change in habitat, which informing and facilitating the establishment of priority areas for habitat restoration and monitoring. | I |
| **Grass Cover Detection Tutorial** | N/A | This product will help the partner create future land cover classifications in order to monitor ongoing ecosystem changes.  | N/A |
| **Change Detection Analysis** | Landsat 5 TM,Landsat 8 OLI | This product will help the partner understand the spatial extent and pattern of change, so they can more effectively streamline the allocation and placement of ecosystem management efforts. | I |
| **Ignition and Flammability-based Fire Risk Map** | Landsat 5 TM, Landsat 8 OLI, Terra MODIS, Aqua MODIS  | The map of fire risk will be disseminated to other stakeholders and used in planning both short- and long-term fire management strategies. | I  |

**Project Handoff Package**

**Transition Plan:**

During week 10, end products were transitioned remotely during a virtual handoff where we presentation our results, answered questions regarding the products, and gave a walkthrough of the change detection methodology so that the ecologists at the KENWR can continue monitoring future changes.

**Team POC:** Katherine Hess, katehess2@gmail.com

**Partner POC**: Dr. Dawn Magness, dawn\_magness@fws.gov

**Handoff Package:**

* Project Summary
* Technical Paper
* Presentation
* Poster
* Project Video
* Grass Cover Detection Tutorial Presentation
* Static Maps of:
	+ Land Cover Classification/ Grass Cover Detection Map
	+ Change Detection Analysis
	+ Kenai Peninsula Ignition and Flammability-based Fire Risk Map

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