**NASA DEVELOP National Program**

**Maryland – Goddard**

*Project Summary – Spring 2018*

**Kenai Ecological Forecasting**

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

**VPS Title:** “What *Kenai* do about Wetland Conversion and Treeline Rise in Alaska?”

**Project Team**

***Project Team*:**

Brendan McAndrew (Project Lead), brendan.mcandrew.88@gmail.com

Kate Hess

Victor Lenske

Sara Lubkin

Megan Maloney

Helen Plattner

***Advisors & Mentors*:**

Dr. John Bolten (NASA Goddard Space Flight Center)

Dr. Adrianna Foster (NASA Goddard Space Flight Center)

Dr. Joseph Spruce (Science Systems & Applications, Inc.)

**Project Overview**

***Project Synopsis*:**

Mean temperatures in Alaska have increased an average of 1.6˚C since the 1950s, an alteration that has resulted in changes in the state’s boreal ecosystems. This warming trend has contributed to elevational rise in alpine treeline and the afforestation of drying peat wetlands. These habitat changes are expected to influence faunal diversity and distribution, as well as regional fire regimes. Using NASA Earth observations, our team monitored and forecasted the spatial extent and distribution of climate-driven vegetation change by producing change detection maps and modeling observed trends to forecast future change. These maps will be used in developing sustainable wildlife management strategies for the Kenai National Wildlife Refuge (KENWR).

***Abstract*:**

Rising temperatures alter growing conditions for vegetation that result in changes to habitat distribution and abundance. In Alaska, these ecological changes present challenges to land managers planning to accommodate species of interest such as Dall’s sheep and ptarmigan. NASA DEVELOP partnered with the Kenai National Wildlife Refuge (KENWR) to identify areas of wetland afforestation and treeline rise on the Kenai Peninsula since 1985 and forecast these trends into 2050 and 2100. The DEVELOP team generated historical land cover classification maps for the Kenai Peninsula from Earth observations acquired by Landsat 5 Thematic Mapper (TM), Landsat 7 Enhanced Thematic Mapper Plus (ETM+), and Landsat 8 Operational Land Imager (OLI). We classified land cover contained in the Landsat imagery by training a random forest classifier with land cover maps for 2001 and 2011 from the USGS National Land Cover Database. We then analyzed the historical land cover maps to identify areas of wetland conversion and treeline rise. The team created forecast maps of these trends to 2050 and 2100 using TerrSet Land Change Modeler (LCM) which can provide KENWR staff with a better understanding of how rates of afforestation vary across the landscape and inform future land management strategies.

**Keywords:**

Remote sensing, Landsat, forest-tundra, alpine, land cover, landscape, afforestation

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

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

***Study Period:*** 1985-2016 with forecasting to 2050 and 2100

***Community Concern:***

* The six-million acre Kenai Peninsula, an ecotone ranging between boreal forest and Pacific coastal rainforest, houses the KENWR and provides extensive ecological, cultural, and economic value.
* As temperatures rise, evapotranspiration dries wetlands, allowing shrubs and trees to colonize and infill these areas, reducing wetland habitat and encroaching into tundra.
* Afforestation has been observed in both (1) treeline rise (white spruce (*Picea glauca*) and mountain hemlock (*Tsuga mertensiana*)), and (2) tree colonization of drying wetlands (black spruce (*Picea mariana*)).
* Alpine-dependent species, such as caribou (*Rangifer trarandus*) and ptarmigan (*Lagopus spp*.), are losing alpine habitat to increasing forest coverage. Vegetative changes are also affecting the quantity and quality of habitat available to wetland associated species.
* Continued afforestation will make spruce forests more abundant and contiguous and change both infestation and fire regime patterns.

***Project Objectives:***

* Map and quantify wetland conversion from 1985 - 2016
* Map and quantify changes in treeline from 1985 - 2016
* Measure loss of wetland habitat due to forest encroachment
* Extrapolate trends to forecast changes in wetland loss and treeline rise into the year 2050 and 2100

**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 KENWR has a legislative mandate under the Refuge System Improvement Act to maintain the biological integrity, diversity, and health of the ecosystems they manage. The refuge cooperates with the Alaska Department of Fish and Game to set game harvest levels that meet these goals. In support of this mission, biological surveys such as the Long Term Ecological Monitoring Program (LTEMP) are conducted in concert with the 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 to anticipate the impacts of accelerated warming and subsequent redistribution of species and habitat, as well as shifts in disturbance regimes such as wildfire and infestation. Maps that reflect these localized trends will support the KENWR’s decision making to maintain the refuge system and to inform harvest recommendations to the Board of Fish & Game.

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

DEVELOP will provide the KENWR with moderate resolution maps of the Kenai Peninsula that will provide a more precise and localized landscape view of recent trends in afforestation of wetlands and treeline rise into alpine habitat. Ecological modeling will forecast these trends into the future in order to inform the KENWR’s conservation management strategy. The quantitative land cover change depicted in these maps will improve understanding of the rates at which woody species are encroaching into wetland and alpine land cover, reducing available habitat for species of interest that require more open landscapes. These maps will be used to estimate future pressures on different land cover types and to inform sustainable harvest levels for species whose populations may change in response to habitat availability. The maps will also provide additional support in community discussions with stakeholders.

**Earth Observations & End Products Overview:**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter** | **Use** |
| **Landsat 5 TM** | Multi-spectral imagery | Imagery was used to create historical land cover classification maps at the landscape scale. |
| **Landsat 7 ETM+** | Multi-spectral imagery | Imagery was used to create historical land cover classification maps at the landscape scale. |
| **Landsat 8 OLI** | Multi-spectral imagery | Imagery was used to create historical land cover classification maps at the landscape scale. |

***Ancillary Datasets:***

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

KENWR legacy vegetation plots – classification of vegetation

USGS National Land Cover Database (NLCD) – classification of vegetation/land cover types

Polar Geospatial Center ArcticDEM – elevation model

***Modeling:***

TerrSet Geospatial Monitoring and Modeling System Land Change Modeler (POC: Dr. James Toledano, Clark Labs) – used to forecast land cover changes to 2050 and 2100 based on historical land cover and climatic trends

***Software & Scripting:***

Google Earth Engine API – acquisition of annual greenest pixel composites of Landsat imagery 1985-2017

Esri ArcGIS 10.4.1 – raster manipulation and analysis, map creation

QGIS 2.14 – raster manipulation and analysis

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **Kenai Peninsula**  **Land/Vegetation**  **Change Detection Maps** | Landsat 5 TM, Landsat 7 ETM+, Landsat 8 OLI | A suite of static visualizations showing empirical rates of land cover change and treeline rise between multiple time steps will help the partner efficiently direct management efforts on the Kenai Peninsula. | I |
| **Kenai Peninsula**  **Land/Vegetation**  **Forecast Maps** | Landsat 5 TM, Landsat 7 ETM+, Landsat 8 OLI | 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. | I |

**Project Handoff Package**

**Transition Plan:**

During week 10, end products were transitioned remotely during a virtual handoff to discuss results and answer any questions regarding the products.

**Team POC:** Brendan McAndrew, brendan.mcandrew.88@gmail.com

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

**Handoff Package:**

* Project summary
* Technical paper
* Presentation
* Poster
* Static maps of:
  + Kenai Peninsula vegetation change detection maps depicting historic afforestation of wetlands and treeline rise using data from January 1985 – December 2016
  + Kenai Peninsula vegetation change forecast maps depicting estimated afforestation of wetlands and treeline rise using a modeled forecast of 2050 and 2100

**References:**

Andersen, 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.

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), 1–15.<https://doi.org/10.1029/2007JG000453>

Morton, J. M., Bowser, M., Berg, E., Magness, D., & Eskelin, T. (2008). Long term ecological monitoring program on the Kenai National Wildlife Refuge, Alaska: an FIA adjunct inventory. In *Proceedings of the Forest Inventory and Analysis (FIA) Symposium* (pp. 1–17).