**NASA DEVELOP National Program**

**** NASA Langley Research Center

*Spring 2017*

**Short Title: Insert here (ex. South Dakota Ecological Forecasting)**

**Subtitle:** Analyzing and Mapping Landscape Disturbance across Glacier National Park Using a Landsat Time Series

**VPS Title:** Disturbing the Peace Park: Landsat Time Series Analysis of Landscape Disturbance in Glacier National Park

**Project Team & Partners**

**Project Team:**

Charlotte Mays (Project Lead), charlotte.e.mays@nasa.gov

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**Advisors & Mentors:**

Dr. Kenton Ross (NASA Langley Research Center)

**Past or Other Contributors:**

Jordan Lubbers

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**Partner Organizations:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| National Park Service, Glacier National Park | Richard Menicke, Geographer | End-User | No |
| NASA Ames Research Center, Biospheric Branch | Dr. Christopher Potter, Senior Research Scientist | Collaborator | No |
| University of Idaho | Dr. Jeffrey Hicke, Associate Professor | Collaborator | No |

**Project Details**

**Applied Sciences National Applications Addressed:** Climate

**Study Area:** Glacier National Park, MT and Waterton Lakes National Park, Alberta, Canada

**Study Period:** 1999 – 2016 (June – September)

**Earth Observations & Parameters:**

Landsat 5, Thematic Mapper (TM) – spectral indices (NDMI, NDVI, and RGI)

Landsat 7, Enhanced Thematic Mapper (ETM+) – spectral indices (NDMI, NDVI, and RGI)

Landsat 8, Operational Land Imager (OLI) – spectral indices (NDMI, NDVI, and RGI)

Spectral Radar Topography Mission (SRTM) version 3 – elevation, slope, and aspect

**Ancillary Datasets Utilized:**

* Natural Agriculture Imagery Program (NAIP) – true color imagery
* Partner *in situ* Data – 1999 Glacier National Park Service - vegetation map
* US Forest Service Aerial Detection Survey (ADS) – disturbance polygons
* NRCS Snow Telemetry (SNOTEL) – snow water equivalent and drought levels
* USGS National Gap Analysis Program (GAP) – classification map
* Partner *in situ* Data -

**Software Utilized:**

* Google Earth Engine API – used for downloading data and analyzing healthy vegetation
* Google Earth – used for digitizing forested areas in “red stage” of bark beetle attack
* ESRI ArcGIS – used for image processing
* Python – used for image processing and automation

**Project Overview**

**80-100 Word Objectives Overview:**

Since 1999, due in part to a changing climate, parasitic insects such as the bark beetle and spruce budworm have caused extensive damage to Glacier National Park’s pine forests. In an effort to accurately determine and analyze this disturbance, our team utilized spectral indices from NASA Earth observations as well as Aerial Detection Survey (ADS) data from the US Forest Service to develop and validate maps of interannual disturbance due to bark beetle and other damage-causing agents such as pathogens.

**Abstract:**

Insects and pathogens cause extensive damage to pine forests in the northwestern United States. Bark beetles in particular cause mortality in pine stands that can impact the timber industry and national parks. Previously, studies have used spectral indices derived from Landsat time series to identify insect disturbance. The team mapped landscape disturbance in Glacier National Park and Waterton Lakes National Park in Alberta, Canada from 1999-2016 using a time series of Normalized Difference Moisture Index (NDMI) and red-green index (RGI) computed from cloud-free Landsat composites. Aerial Detection Survey polygons were used to fine tune thresholds, targeting the classification of moderate disturbance toward insect disturbance. Insects and pathogens were the primary focus of this classification scheme, however, due to the level of ambiguity in the ADS data and because NDMI is sensitive to various disturbance types, the study opted to map all moderate disturbance. To determine the thresholds for these categories, spectral indices from the 2013-2014 and 2015-2016 interannual periods were subset to ADS polygons, fire data from the National Park Service, and polygons representing healthy forest as digitized from high resolution NAIP imagery. Histograms were then computed for each of these DNDMI subsets. The resulting histograms were overlayed for comparison and thresholds were determined based on the distribution of each category. RGI was then incorporated to further target the red stage of bark beetle attack in the moderate disturbance category. Maps of persistent disturbance over a time series of five inter-annual periods were created from the resulting maps of interannual disturbance. The study programmatically generated all maps and histograms with Python for efficiency and modularity, so that the methodology may be applied to map future outbreaks.

**Keywords:**

Remote Sensing, Landsat, disturbance, bark beetle, time series, image classification

**Community Concerns:**

* Landscape disturbances are occurring at an unprecedented rate due to a changing climate.
* From 1999-2016 Glacier National Park has been subject to increases in large ecological disturbances from insects such as the bark beetle and pathogens. As a result, the forestry industry and surrounding communities face potential economic setbacks.
* Future ecological impacts have been predicted for the Park, however the scope and the volume of these impacts are not thoroughly understood.
* The aesthetic value of Glacier National Park is being compromised, which could impact tourism.

**Current Management Practices & Policies**:

The National Park Service uses *in situ* monitoring along with Landsat data to evaluate disturbances at both the ground level and at the overall Park level. However, Glacier National Park has only used Landsat-derived products to examine fires, and fly over data collected by the U.S. Forest Service’s ADS program to monitor insect disturbance. Richard Menicke is currently collaborating with Dr. Christopher Potter in order to expand the use of Landsat to conduct a species-level or ecological unit-level classification of the Park. Dr. Jeffrey Hicke is also contributing his knowledge from previous studies in collaboration with the other partners.

**Decision Support Tools & Benefits:**

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| --- | --- | --- | --- |
| **End-Product** | **Earth Observations Used** | **Benefit & Impact** | **Software**  **Release** |
| Interannual Vegetation Disturbances Maps | Landsat 5 TM; Landsat 7 ETM+; Landsat 8 OLI | Provides a synoptic summary of disturbance through image classification of Landsat imagery, and consequently, an improved awareness of range and severity of these disturbances for the use of park resource management | I |
| Frequency of Disturbance Maps | Landsat 5 TM; Landsat 7 ETM+; Landsat 8 OLI; | Maps representing persistent disturbance within ranges of interannual periods; development of threshold methodology, comparison to NAIP imagery | I |
| Tutorial for High School Students | Landsat 5 TM; Landsat 7 ETM+; Landsat 8 OLI | Will create a PDF tutorial that covers introductory GIS and remote sensing as it applies to disturbance mapping in GNP. Will help expand the interest and technical skills in high school students | III |
| Automated Decision Tree Threshold-Based Classification Methodology | Landsat 5 TM; Landsat 7 ETM+; Landsat 8 OLI; SRTM | Python script will classify disturbance thresholds to determine areas more or less impacted by specific disturbances and will automate map generation to the fullest extent possible | III |