**NASA DEVELOP National Program**

 NASA Langley Research Center

*Summer 2017*

**Short Title: Pacific Southwest Cross-Cutting**

**Subtitle:** Utilizing NASA Earth Observations to Develop a Land Use Change Detection Tool for Habitat Conservation Plan Areas

**VPS Title:** Surveying the Southwest: Land Use Change in Protected Areas

**Project Team**

**Project Team:**

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**Project Overview**

**80-100 Word Objectives Overview:**

The goal of this project was to use Landsat 5, Landsat 8, and Sentinel-2 to create a tool within Google Earth Engine that identifies unexpected land use change within Habitat Conservation Plan (HCP) areas in the Pacific Southwest. Currently, the United States Fish and Wildlife Service (USFWS) is restricted in staffing which increases the difficulty of monitoring management activity on lands under HCPs. The end product will provide the means to remotely measure unexpected land use change, allowing more efficient supervision of HCPs by the USFWS.

**Abstract:**

Habitat Conservation Plans (HCPs) were designed to protect and manage areas where desired economic development is in conflict with the needs of threatened and endangered species. Each plan is developed through collaboration between United States Fish and Wildlife Service (USFWS) and a landowner or other project proponent. Regulations restrict activities within HCP boundaries to minimize impacts to listed species while still allowing for land development. The USFWS does not have the capacity to closely monitor and assess the millions of acres of private- and publically-owned lands to ensure compliance with restrictions. In order to assist monitoring efforts by the USFWS, a methodology was constructed that uses remote sensing data and the Normalized Difference Vegetation Index (NDVI) to detect land use change. Past land use change from 1995 to 2017 in the Pacific Southwest HCPs was analyzed. This methodology used publically available satellite data from Landsat 5, Landsat 8, and Sentinel-2, and was implemented in the open source Google Earth Engine (GEE) API. The USFWS will be able to use this tool on the GEE platform to continue evaluating HPCs for disturbance, saving significant travel time and effort.

**Keywords:**

Remote sensing, Normalized Difference Vegetation Index (NDVI), Normalized Burn Ratio (NBR), land use change, Google Earth Engine API, Landsat, Sentinel

**Partner Organizations:**

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| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| US Fish and Wildlife Service, Pacific Southwest Region Ecological Services Program | Pat Lineback, Regional GIS Coordinator;  Dan Cox, Regional Habitat Conservation Coordinator | End User | No |
| US Fish and Wildlife Service, Midwest Region  National Wetland Inventory | Brian Huberty, Regional NWI and Remote Sensing Coordinator | Collaborator | No |

**Community Concerns:**

* The USFWS is responsible for monitoring millions of acres of private and publically owned lands and easements.
* The USFWS has limited capacity in staff to adequately conduct monitoring of HCPs.
* HCPs are becoming more common and successful, but there are no independent business processes or tools in place to evaluate these areas and determine the extent of potential disturbance.

**Current Decision-Making Practices & Policies**:

To help reduce the conflict between economic development and the protection of endangered species, HCPs were created in 1982 by an amendment to the Endangered Species Act (ESA). The development of an HCP is part of the process of applying for an Incidental Take Permit, which allows landowners or other project proponents to undertake activities normally restricted by the presence of endangered species. HCPs are developed in collaboration with the USFWS and must outline the expected impacts to endangered species, steps to minimize those impacts, and mitigation actions for any impacts that cannot be avoided. Landowners or project proponents carry out the management activities within the HCPs and send reports to HCP biologists within the USFWS. Each biologist manages multiple HCPs, leaving very little time to ground truth every report that is sent to them. Therefore, there is no easy way for the biologist to quickly identify potential significant changes occurring within HCPs.

**Decision Support Tools & Benefits:**

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| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used** | **Partner Benefit & Use** | **Software**  **Release** |
| Landscape Anomaly Detection Tool | Landsat 8 OLI,  Sentinel-2A MSI | This decision-support tool will assess landscape disturbances in HCP areas. Areas flagged with moderate- to large-scale disturbance will help focus program managers’ *in situ* monitoring efforts. | III |
| Maps Depicting Trends in Land Use Change | Landsat 8 OLI,  Sentinel-2A MSI | Annual land use change maps will be used to assess potential trends in land use change across HCP areas. They will also be used to determine the validity of the decision-support tool. | I |

**Project Benefit to End User**:

The USFWS would like to incorporate remote sensing to more efficiently monitor land use changes within HCP boundaries for management and conservation decisions. Maps showing significant land use change will assist biologists in determining areas of interest and land use trends across multiple locations. Understanding the extent of land use change across different areas can help the USFWS determine the causes of those transitions, leading to appropriate management reforms. This will help the USFWS respond both to more natural events like drought or fire and to anthropogenic events. These end products will be the first steps in improving our partner’s ability to monitor HCPs and other conservation areas. A better understanding of the changes occurring in the area of interest would allow USFWS to react to these changes faster and more accurately, preventing further impacts to endangered species.

**Project Details**

**Applied Sciences National Applications Addressed:** Cross-Cutting, Ecological Forecasting, Agriculture

**Study Area:** CA, focus on Riverside County, CA

**Study Period:** January 1995 to May 2017

**Earth Observations & Parameters:**

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| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| Landsat 5 Thematic Mapper (TM) | Surface reflectance | Landsat 5 will be used to calculate NDVI to establish land use change for 1995-2013. |
| Landsat 8 Operational Land Imager (OLI) | Surface reflectance | Landsat 8 will be used to calculate NDVI for 2013-present. |
| Sentinel-2 MultiSpectral Imager (MSI) | Surface reflectance | Sentinel-2 will be used to calculate NDVI with a higher resolution than Landsat for 2015-present. |

**Ancillary Datasets Utilized:**

* Los Angeles County Fire Department Fire Perimeter Polygons – validate burn ratio results
* US Fish and Wildlife Habitat Conservation Plan dataset – shapefiles of study areas
* USDA NASS Cropland Data Layers – help determine possible causation of land use change
* Digital Globe – validate Landsat-based results

**Software Utilized:**

* Google Earth Engine API – manipulate data, create methodology
* Esri ArcGIS – manipulate data, create visuals

**Project Handoff Package**

**Transition Plan:**

At the end of the first term of this project, the team will provide partners at the USFWS with maps displaying land use change in their study area. A demonstration of what the GEE code is capable of at that point will be given through a videoconference or webinar. We will show stills of several results and provide explanations of the process in order to avoid sharing the code before software release has been completed.

*Software Release Plan*: The code will be finalized by the participants of the second term of this project and then released to the partners after it is approved by NASA’s software release authority. The code is being developed in Google Earth Engine API, which has a web-based code editor that the partners will be able to easily access and use themselves. A tutorial and explanation of how to use the code and adjust it to their future needs will be provided by the second term. We will provide a detailed report of our progress and methodology for the code to the second term to facilitate the creation of the tutorial.

*Project Continuation Plan*: At the end of the first term, the team will provide a map package generated by the current version of the code, a preliminary workflow for the methodology behind the code, and a visual demonstration of the code and results. During the second term, the participants will provide updated maps generated by the finalized code and a written tutorial for implementing this methodology. There will be a videoconference to explain the use of the code. The final software will be provided to the partners after the final term.

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**Software Release POC**: Elizabeth Dyer, elizkdyer@gmail.com

**Partner POC**: Pat Lineback, pat\_lineback@fws.gov

**Handoff Package:**

* Map package of yearly land use change from 1995-2017 in HCPs in the Pacific Southwest. The maps will include areas that experienced fires, and areas that saw significant vegetation loss or gain based on NDVI.
* Graphs from data results (ex: time series of NDVI, NBR, vegetation gain/loss)
* Technical report
* Flowchart of code process