**NASA DEVELOP National Program**

**Virginia – Langley**

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*Project Summary – Fall 2017*

**Pacific Southwest Cross-Cutting II**

*Improving Detection of Land Use Change in Habitat Conservation Plan Areas Using NASA Earth Observations and a Landscape Anomaly Detection Tool*

**VPS Title:** Waiting on the World to Change

**Project Team**

***Project Team*:**

Kimberly Johnson (Project Lead), kimberlybuskjohnson@gmail.com

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***Advisors & Mentors*:**

Dr. Kenton Ross (NASA Langley Research Center)

***Past or Other Contributors*:**

Sean Robison

Liz Dyer

Katie Thomas

**Project Overview**

***Project Synopsis*:** The objective of this project was to create a user-friendly tool that allows biologists and conservationists at the US Fish and Wildlife Service (USFWS) to identify land use change in the Pacific Southwest region (California, Nevada, and Oregon). The tool was built in the Google Earth Engine API and utilizes data from Landsat 5 TM, Landsat 7 ETM+, Landsat 8 OLI, and Sentinel-2 MSI to detect land use change remotely. This tool will allow the USFWS to remotely observe Habitat Conservation Plan (HCP) areas to determine if conserved areas are being disturbed, allowing them to more efficiently use time and monetary resources by targeting field visits to areas that are experiencing the most land use change.

***Abstract*:**

The US Fish and Wildlife Service (USFWS) monitors and approves the creation of Habitat Conservation Plan (HCP) areas under the Endangered Species Act (ESA). Habitat Conservation Plans allow economic development in areas that have threatened and endangered species with the agreement that the developer provide a necessary alternative habitat for the species that rely on areas being developed. The USFWS creates each HCP with the landowner or developer, and the HCP is tailored to fit the needs of both the proposed development or land use and the species that will be affected. While regulations limit the activities and development in HCP areas to minimize impacts on species, it is difficult for the USFWS to effectively monitor all the land that falls within HCPs. Partnering with the USFWS, a user-friendly interface was developed in the Google Earth Engine (GEE) API to display remotely sensed imagery obtained from Landsat 5 TM, Landsat 7 ETM+, Landsat 8 OLI, and Sentinel-2 MSI satellites. These data were used to remotely determine past land use changes in the HCPs from 2000 to 2017. The user interface displays Normalized Difference Vegetative Index (NDVI), Relative Green Index, change and percent change in Relative Green Index, Normalized Burn Ratio (NBR), and National Agriculture Imagery Program data to assist in land use change evaluation. This tool will be used by biologists and conservationists at the USFWS to assess land use change.

**Keywords:** Habitat Conservation Plan (HCP), land use change, United States Fish and Wildlife Service (USFWS), Graphical User Interface, Google Earth Engine, Landsat, Sentinel, Relative Green (RG)

***National Application Areas Addressed:*** Cross-Cutting, Ecological Forecasting, Agriculture

***Study Location:*** Pacific Southwest region, CA, NV, OR

***Study Period:*** January 2000 – April 2017

***Community Concern:***

* There are currently 136 HCP areas in the Pacific Southwest region (USFWS Region 8), which cover more than 84 million acres.
* Budgetary and resource constraints prevent the USFWS from ground truthing all HCP areas as a way of checking the agreements.
* Protecting endangered and threatened species preserves biodiversity.
* The USFWS requires a tool to remotely detect the land use changes that threaten HCPs.

***Project Objectives:***

* Create a Landscape Anomaly Detection Tool that allows the user to identify the time and HCP location in the Pacific Southwest for which they are interested in detecting land use change
* Use satellite imagery in Google Earth Engine to calculate NDVI and relative greenness for the time and location of interest
* Refine the tool to allow the user to overlay other layers, including the US Department of Agriculture National Agricultural Statistics Section cropland data and NBR, to try to explain any land use changes with reasons other than anthropogenic development
* Automate the process for the user to export their work to use as needed in the future, such as in reports about the HCPs they oversee

***Previous Term:*** 2017 Summer (LaRC) – Pacific Southwest Cross-Cutting

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **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 National Wetland Inventory and Remote Sensing Coordinator | Collaborator | No |

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

The ESA was created in 1973 to conserve endangered and threatened species and prohibit their removal or harm. An amendment to the ESA in 1982 allowed for activities leading to the incidental take of listed species, as part of an Incidental Take Permit. For an Incidental Take Permit to be approved by the USFWS it must be accompanied by an HCP, which must reduce and mitigate the incidental take of listed species as well as provide funding to maintain the HCP into the future. Furthermore, the project proponents must manage and report on the HCP to the USFWS. The USFWS employs biologists who each oversee multiple HCPs. With limited funding and resources, and an increasing number of HCPs being created, ground truthing has become more challenging and the USFWS currently does not use remote sensing or NASA Earth observations to observe changes occurring in the HCPs.

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

The Landscape Anomaly Detection Tool being developed for the USFWS utilizes remote sensing data to detect land use changes and assist in identification of areas of interest for further investigation. Identification of land use changes across different areas will aid in the preliminary investigation of the causes of land use changes, whether due to anthropogenic activities or natural causes. Additionally, detecting changes in the HCPs will assist in preventing further endangerment of protected species, expand the USFWS’s ability to regulate the HCPs, and verify landowner or proponent reporting. Increased awareness of land use changes in current HCPs could lead to healthier HCP areas in the future and enhance conservation management assessments in current and future HCPs.

**Earth Observations & End Products Overview**

***Earth Observations:***

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| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **Landsat 5 TM** | Surface reflectance | Landsat imagery will be used to detect land use change by calculating NDVI and Relative Greenness from 2000-2012. |
| **Landsat 7 ETM+** | Surface reflectance | Landsat imagery will be used to detect land use change by calculating NDVI and Relative Greenness from 2012-2013. |
| **Landsat 8 OLI** | Surface reflectance | Landsat imagery will be used to detect land use change by calculating NDVI and Relative Greenness from 2013-April 2017. |
| **Sentinel-2 MSI** | Surface reflectance | Sentinel-2 imagery will be used to compare with Landsat-based land use change results. |

***Ancillary Datasets:***

US Fish and Wildlife Habitat Conservation Plan dataset – shapefiles of Habitat Conservation Plan study areas

US Department of Agriculture National Agricultural Statistics Section (NASS) – Cropland Data Layers

US Department of Agriculture Farm Service Agency, National Agriculture Imagery Program (NAIP) – High resolution imagery

***Software & Scripting:***

Google Earth Engine API – manipulate data, create methodology

Esri ArcGIS 10.5 – manipulate data, create visuals

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| Landscape Anomaly Detection Tool | Landsat 5 TM, Landsat 7 ETM+, Landsat 8 OLI, Sentinel-2 MSI | This decision-support tool will help the USFWS detect landscape disturbances in HCP areas, allowing them to focus *in situ* efforts in areas that experience the most disturbance. | III |
| Workflow Document and Tutorial | N/A | These detailed documents will aid the USFWS in disseminating the landscape anomaly detection tool within their organization, allowing the tool to be extended to other use cases in the future. | N/A |
| Land Use Change Maps | Landsat 5 TM, Landsat 7 ETM+, Landsat 8 OLI, Sentinel-2 MSI | These maps will provide land use change data prior to software release demonstrating the Landscape Anomaly Detection Tool’s effectiveness. | I |

**Project Handoff Package**

**Transition Plan:**

Following the 2017 Fall term, the NASA DEVELOP team will provide land use change maps, the technical report, and a workflow document to USFWS partners. The Google Earth Engine mapping tool will be available after software release. If the code has passed the government-use level of software release before the end of the term, the team will show the USFWS the tool through a videoconference or webinar.

*Software Release Plan*: The software for the Landscape Anomaly Detection Tool will undergo the software release process and falls into software release category III, which will take time to process through NASA to approve it as open source. Upon release of the software, it will be uploaded to the NASA DEVELOP GitHub for the partners to download and use. While the software will take some time to be approved, the Pacific Southwest Cross-Cutting II team will provide the partner with land use change maps exported from the software. Additionally, the team will provide workflow and tutorial documents describing how to use the software and interpret the outputs of the tool.

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**Software Release POC**: Jarell Perez, DEVELOP.jarell@gmail.com

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**Handoff Package:**

* Technical Report
* Workflow and Tutorial Documents
* Map package including land use change maps assessing land use change across various HCPs in the Pacific Southwest region, confirming the usability of the Landscape Anomaly Detection Tool

**References:**

U.S. Department of the Interior Fish and Wildlife Service. (2016, December 21). Habitat Conservation Planning and Incidental Take Permit Processing Handbook. Retrieved from <https://www.fws.gov/endangered/esa-library/pdf/HCP_Handbook.pdf>

U.S. Fish and Wildlife Service Endangered Species Program. (2011, April). Habitat Conservation Plans Under the Endangered Species Act. Retrieved from <https://www.fws.gov/endangered/esa-library/pdf/hcp.pdf>