**Okefenokee Water Resources**

*Using Earth Observations to Assess Hydrologic Changes and Wildfire Risk in the Okefenokee Swamp*

**Project Team**

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**Project Overview**

***Project Synopsis:***

The Okefenokee Swamp is a unique ecosystem that stores carbon in its deep peatlands, protects biodiversity, and offers various recreational and economic opportunities for local residents. The swamp has experienced several damaging fires in recent history, and staff at the Okefenokee Swamp are interested in applying a deeper understanding of hydrologic change and wildfire risk to the management of this pristine swamp. This project used remote sensing to assess the feasibility of identifying trends in fire location and severity, tracking hydrologic changes that could lead to increased fire risk, and detecting vegetation changes in the months following a wildfire event.

***Abstract:***

The Okefenokee Swamp is a vital ecosystem known for its protection of biodiversity, peatland carbon sinks, and recreational and economic opportunities for local residents. The swamp has experienced several wildfires since the 1990s, and new development along the borders of Okefenokee National Wildlife Refuge (ONWR) threatens to alter hydrologic activity and increase fire frequency. NASA DEVELOP partnered with staff at the ONWR to determine the feasibility of using satellite imagery to assess wildfire risk and map changes in vegetation cover. Using data from NASA satellites Landsat 7 Enhanced Thematic Mapper Plus (ETM+) and Landsat 8 Operational Land Imager (OLI), Soil Moisture Active Passive (SMAP) data from the USDA’s Crop Condition and Soil Moisture Analytics Tool (Crop-CASMA), European Space Agency (ESA) Sentinel-1 C-Band Synthetic Aperture Radar (C-SAR), and Sentinel-2 Multispectral Instrument (MSI), the DEVELOP team assessed the relationship between hydrologic change, vegetation cover, and wildfire risk in the swamp. Results showed that the southern portion of ONWR has been burned the most since 1990 and has greater water stability than other areas of the refuge. The team also found that the largest pockets of mature forests remain in the northernmost regions. Soil moisture anomaly readings may serve as an indicator of fire conditions. The team used these results to create a vegetation map, a swamp water visibility time series map, a historical wildfire correlation analysis, and a methodology tutorial. These products will assist the ONWR in making informed management decisions about the future of the Okefenokee Swamp. 

***Key Terms:*** wildfire analysis, vegetation mapping, peat deposits, remote sensing, wetland conservation

***National Application Area Addressed:*** Water Resources

***Study Location:*** Okefenokee National Wildlife Refuge, GA

***Study Period:*** January 1990 to January 2022

***Community Concerns:***

* The Okefenokee Swamp is one of the largest preserved freshwater systems in the world and offers unique habitat for a variety of endangered species. Increased wildfire activity threatens the integrity of the swamp and its incredible biodiversity.
* Over 600,000 individuals visit the Okefenokee Swamp every year, offering a host of recreational and economic opportunities for local residents. Any wildfires that damage the swamp also pose a threat to nearby property, local economy, and local air quality.
* Heavy mineral mining and increased development near the Okefenokee Swamp have the potential to expose the swamp to lowered water levels and thus increased fire frequency, so there is a need to understand current hydrologic trends and the correlation of those trends with wildfire vulnerability to optimize ecosystem management.
* The peat deposits within the Okefenokee Swamp are vital carbon sinks, and extensive damage from wildfire or external industry could release large quantities of carbon into the atmosphere and water system.

***Project Objectives:***

* Create burn severity maps visualizing the extent of burn damage from the 2017 West Mimes Fire
* Update historic vegetation maps utilizing Earth observations to identify correlations between land use changes, hydrology, and fire risk in the Okefenokee Swamp
* Assess wildfire vulnerability using Earth observations and quantify areas of greatest concern
* Create a swamp water level timeseries and identify correlations between hydrologic trends, land cover, and wildfire burn scars

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **Contact (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Okefenokee Swamp Park** | Kim Bednarek, Executive Director | End User | Yes |
| **US Fish and Wildlife Service, Okefenokee National Wildlife Refuge** | Michael Lusk, Manager | End User | No |

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

The Okenfenokee Swamp Park (OSP) is a private partner to the Okefenokee National Wildlife Refuge (ONWR) and works to engage the general public with the Okefenokee Swamp through education and ecotourism. The ONWR is a non-profit organization and works in partnership with government, corporate, educational, and conservation organizations to fund projects and encourage community engagement. The goal for the refuge is to protect ecological integrity and species diversity for future generations and to embrace the cultural heritage of the swamp. Both organizations are currently working towards achieving conservation goals outlined in the 2006 “Okefenokee National Wildlife Refuge Comprehensive Conservation Plan” (USFWS, 2006) While the end users do have an experienced Geographic Information Systems (GIS) staffer and have conducted vegetation mapping and wildfire risk analysis, they do not currently use Earth Observations in their decision-making process. Instead, they have historically relied on data from past research partners and field work.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **Landsat 7 ETM+** | Surface Reflectance | The team used Near Infrared and Shortwave Infrared bands to calculate Normalized Burn Ratio (NBR) and Difference Normalized Burn Ratio (dNBR) for 1999–2013. NBR and dNBR were then used to analyze burn scarring and burn severity from known wildfires. |
| **Landsat 8 OLI** | Surface Reflectance | The team used Near Infrared and Shortwave Infrared bands to calculate Normalized Burn Ratio (NBR) and Difference Normalized Burn Ratio (dNBR) for 2013–2021. NBR and dNBR were then used to analyze burn scarring and burn severity from known wildfires. |
| **Sentinel-1 C-SAR** | C-Band Backscatter | The team used C-Band Backscatter to analyze water levels throughout the swamp and determined where the water area was expanding or shrinking. |
| **Sentinel-2 MSI** | True Color & False Color Visualizations | The team used true color and false color visualizations to produce an unsupervised classification of the different vegetation types within the refuge. |
| **SMAP** | Soil Moisture | The team used SMAP soil moisture data to determine areas of greatest wildfire risk. |

***Software & Scripting:***

* Google Earth Engine API – Data compilation, manipulation, and calculation
* Esri ArcGIS Pro 2.9.0 – Raster and data manipulation, map creation, and change detection analysis
* Microsoft Excel – Statistical analysis

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **Historical Wildfire Burn Severity Maps** | Landsat 7 ETM+  Landsat 8 OLI | The 3 maps of historical wildfires will help partners explore wildfire trends in terms of location and burn severity. This will strengthen the partners’ understanding of wildfire risk and inform management strategies within the refuge. | N/A |
| **Vegetation Map** | Sentinel-2 MSI | This assessment will update the partner’s vegetation maps to reflect recent fire damage and identify areas where vegetation and land use changes might be affecting hydrologic changes in the refuge. It will also help the partners identify current threats to the wetlands. | N/A |
| **Swamp Water Visibility Time Series Maps** | Sentinel-1 C-SAR | These maps will help the partners understand wildfire risk by pinpointing areas where land use changes might be responsible for lowered water levels across the refuge. | N/A |
| **Soil Moisture Correlation Analysis** | Landsat 7 ETM+  Landsat 8 OLI  SMAP | This analysis will help the partners determine the relationship between historic wildfire events and trends in soil moisture and water level. This will strengthen the partners’ understanding of how various environmental changes affect wildfire risk on the refuge. |  |
| **Methodology Tutorial** | Landsat 7 ETM+  Landsat 8 OLI  Sentinel-1 C-SAR  Sentinel-2 MSI  SMAP | This tutorial will demonstrate how to use remote sensing to create vegetation maps and assess wildfire risk and severity. | N/A |

***Product Benefit to End User:***

Although the end users have a dedicated GIS specialist, they do not currently use remote sensing in their management of the Okefenokee Swamp. Therefore, the end products will help the partners conduct future research with greater efficiency and accuracy by building partner capacity to locate and manipulate data from various Earth observations. The updated vegetation and fire maps will assist the partners in better understanding the relationship between wildfire risk, hydrologic trends, and peat deposits. The products will assist the partners in making more informed management decisions about the future of the Okefenokee Swamp and in achieving their conservation goals.

**References**

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