**Lower Illinois River Valley Ecological Forecasting**

*Inundation Mapping of the Lower Illinois River Valley Using Synthetic Aperture Radar and Optical Satellite Imagery for Wetland Conservation and Restoration Prioritization Efforts*

**Project Team**

***Project Team:***

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**Project Overview**

***Project Synopsis:***

This project focused on the feasibility of mapping inundation extent and duration along the Lower Illinois River Valley using Sentinel-1 C-SAR imagery to enhance decision making for prioritization of wetland restoration projects. Partnered with the Great Rivers Land Trust, the National Great Rivers Research & Education Center, Principia College, and the American Geophysical Union’s Thriving Earth Exchange, these end products will support grant writing, awareness of land at-risk for flooding, and the formation of wetland mitigation banks.

***Abstract:***

The Lower Illinois River Valley (LIRV) is home to some of the richest agricultural lands in the United States and its wetlands provide key ecosystem services like clean water and flood reduction. It has also experienced extensive degradation due to development and urban pollution. The Great Rivers Land Trust (GRLT), the National Great Rivers Research & Education Center, Principia College, and the American Geophysical Union’s (AGU) Thriving Earth Exchange sought to incorporate inundation and surface water extent layers into their geodatabases to more accurately identify priority areas for wetland restoration. This project aimed to determine the feasibility of detecting inundation extent and duration along the valley using remotely sensed data. The team used Sentinel-1 C-band Synthetic Aperture Radar (SAR) data to classify open water and inundated vegetation within the study site. The open water classification was compared to Dynamic Surface Water Extent (DSWE) derived from Landsat 8 Operational Land Imager. The team successfully created layers of inundation minimum and maximum extent, as well as inundation duration across the study area for 2019 and 2020. The open water classification resulted in an overall accuracy of 86% when validated against DSWE classifications. These analyses will help end users to identify high priority areas along the LIRV best suited for land conversion projects in the future.

***Key Terms:***

Landsat 8 OLI, Sentinel-1 C-SAR, inundation detection, DSWE, mixed wetland, restoration

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

***Study Location:*** Lower Illinois River Valley, IL

***Study Period:*** 2019 and 2020 (March - November)

***Community Concerns:***

* Wetlands are important because they provide habitat for sensitive and native species, as well as ecosystem services like erosion control, flood prevention, and water filtration
* Urbanization and intensive agriculture have caused extensive wetland degradation in the United States, particularly in agricultural hubs like the Lower Illinois River Valley (LIRV)
* Restoring and conserving wetlands would combat erosion, agricultural run-off, poor water quality, loss of native habitat, invasive species, and flash flooding.
* Preserving and creating access to open space became of increasing concern during the COVID-19 pandemic
* Providing additional opportunities for recreational activities that already enjoy popularity, such as hunting and fishing

***Project Objectives:***

* Generate inundation extent and duration layers of the LIRV for 2019 and 2020
* Compare various metrics for detecting inundation
* Determine feasibility for further incorporation of remotely sensed products into the Great Rivers Land Trust’s (GRLT) land acquisition decision-making practices beyond the study period.

**Partner Overview**

***Partner Organizations:***

|  |  |  |
| --- | --- | --- |
| **Organization** | **Contact (Name, Position/Title)** | **Partner Type** |
| **Great Rivers Land Trust** | Alley Ringhausen, Executive Director; David Holman, GIS Consultant | End User |
| **National Great Rivers Research & Education Center** | Dr. Lyle Guyon, Terrestrial Ecologist | Collaborator |
| **American Geophysical Union, Thriving Earth Exchange** | Zavia Jenkins, Community Science Fellow | Collaborator |
| **Principia College** | Dr. Marie Farson, Assistant Professor | Collaborator |

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

GRLT purchases land for conservation and restoration in an effort to protect scenic and ecologically valuable land within the floodplain of the Mississippi, Illinois, and Missouri rivers. The GRLT is particularly interested in procuring farmland for conversion to functioning mixed wetlands, also referred to as forest floodplains. Deciding which land parcels are both available and suitable for purchase is a crucial first step in this work. With the Lower Illinois River Valley being a major agricultural hub that is sensitive to flood events, identifying inundation duration assists the end user’s ability to communicate this important information to government agencies who must also consider impacts to the state’s agricultural industry. The GRLT considers a host of factors in this decision, like proximity to waterways, vegetative cover, and soil quality. They do not currently utilize remote sensing data to gauge these factors.

**Earth Observations & End Products Overview**

***Earth Observations:***

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| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Sentinel-1 C-band Synthetic Aperture Radar (C-SAR)** | Backscatter values, surface roughness  | The VH polarization band and VV/VH ratio band were used to detect open water and inundated vegetation, respectively, throughout 2019 and 2020. |
| **Landsat 8 Operational Land Imager (OLI)** | Dynamic Surface Water Extent (DSWE), water presence | The USGS DSWE product was used to validate open water extent. |

***Ancillary Datasets:***

* United States Geological Survey National Land Cover Database – Used to correct for land cover types with similar backscatter signatures
* United States Army Corps of Engineers National Levee Database – Used to contextualize results
* United States Geological Service National Water Information System – Used to pinpoint times of high flooding and confirm initial results

***Software & Scripting:***

* Google Earth Engine JavaScript API – Map inundation extent and duration from remotely sensed data for use in wetland identification
* Esri ArcGIS Pro 2.8.7– Create visuals for presentations and reports

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used**  | **Partner Benefit & Use** | **Software Release Category** |
| **Inundation Extent Maps** | Landsat 8 OLI Sentinel-1 C-SAR | Partners will incorporate these maps into their online geodatabase and viewing portal to help assess which land parcels to buy for restoration and conservation purposes.  | I |
| **Inundation Duration Maps** | Sentinel-1 C-SAR | Partners will incorporate these maps into their online geodatabase and viewing portal to help assess which land parcels to buy for restoration and conservation purposes.  | I |

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

The end products will expand the utility of remote sensing in wetland identification and monitoring. To date, there has been limited fine scale mapping of inundation levels in areas along the Lower Illinois River Valley. Our end users will be able to interpret the inundation extent and duration layers generated to identify wetlands of high conservation value and potential restoration sites. End users can combine these layers with additional classifiers to identify land type based on their working definition of a wetland. Additionally, we will provide our end user with a methodology for mapping inundation as weather and hydrological patterns continue to change.

**References**

Thriving Earth Exchange. (2022). *Identifying and prioritizing wetland restoration sites in the Lower Illinois River Valley*.

AGU Thriving Earth Exchange. <https://thrivingearthexchange.org/project/lower_illinois_river_valley-il/>

Guyon, L., Sloan, J., Van Essen, R., & Corcoran, M. (2016). Floodplain Forests and Water Quality in the

Upper Mississippi River System. *Report to the National Audubon Society.*

<http://www.ngrrec.org/uploadedFiles/Pages/Research_Program/Floodplain_Forests_and_Water_Quallity.pdf>