Wetland Dynamics in the Cache Slough Complex Using Remote Sensing

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1. Introduction

Located in northern California, the Cache Slough Complex (CSC) is a key wetland within the Sacramento–San Joaquin Delta, at the southern end of the Yolo Bypass. The CSC provides critical flood protection and water supply functions, and serves as important habitat for endangered species such as the Delta smelt (Hypomesus transpacificus) and the Sacramento winter-run Chinook salmon (Oncorhynchus tshawytscha). Its seasonal flooding and vegetation dynamics make it an ideal site for studying wetland changes through remote sensing. **Using remote sensing, how do seasonal patterns of wetland moisture vary across the Cache Slough Complex?**

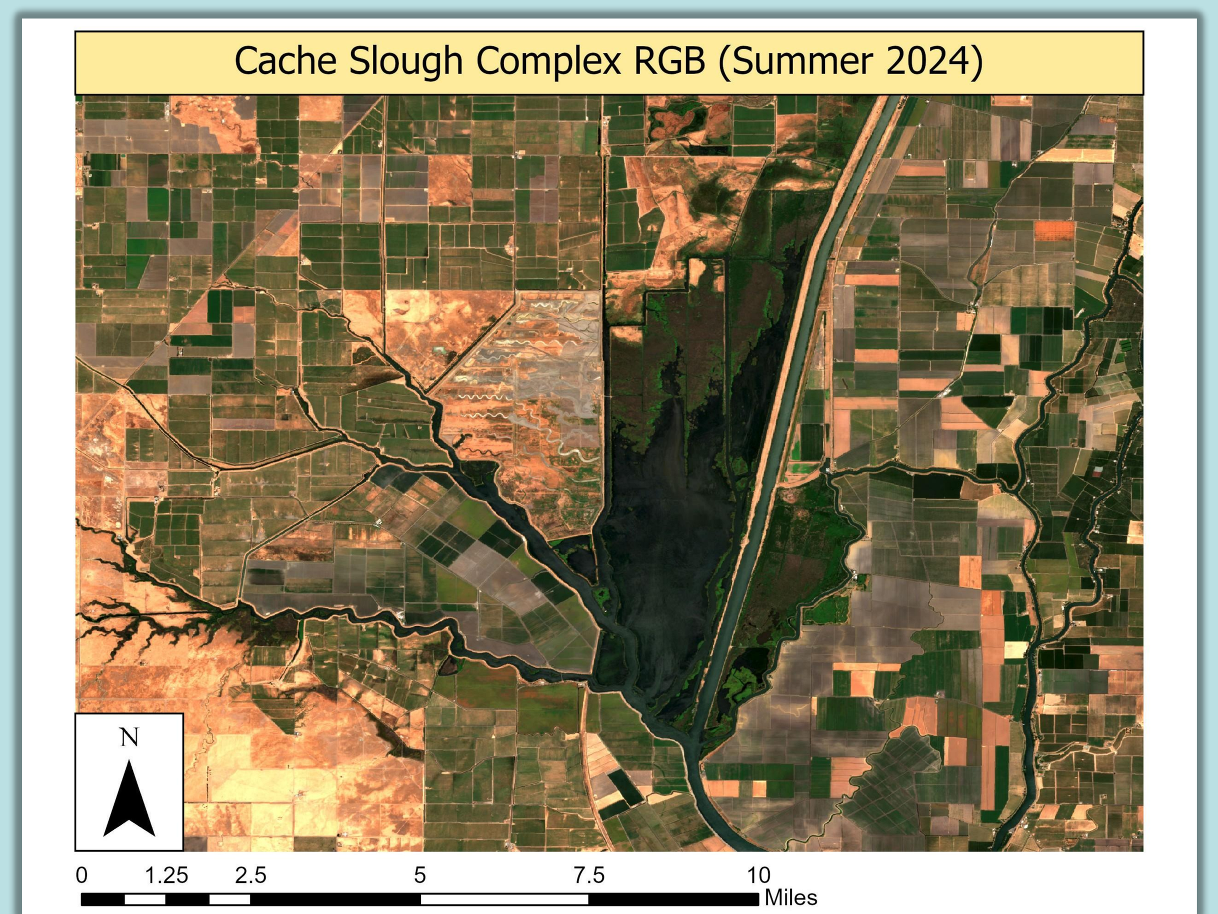

Figure 1. Cache Slough Complex Composite median image in true color from Summer 2024 (6/1/2024 – 8/31/2024)

3. Results

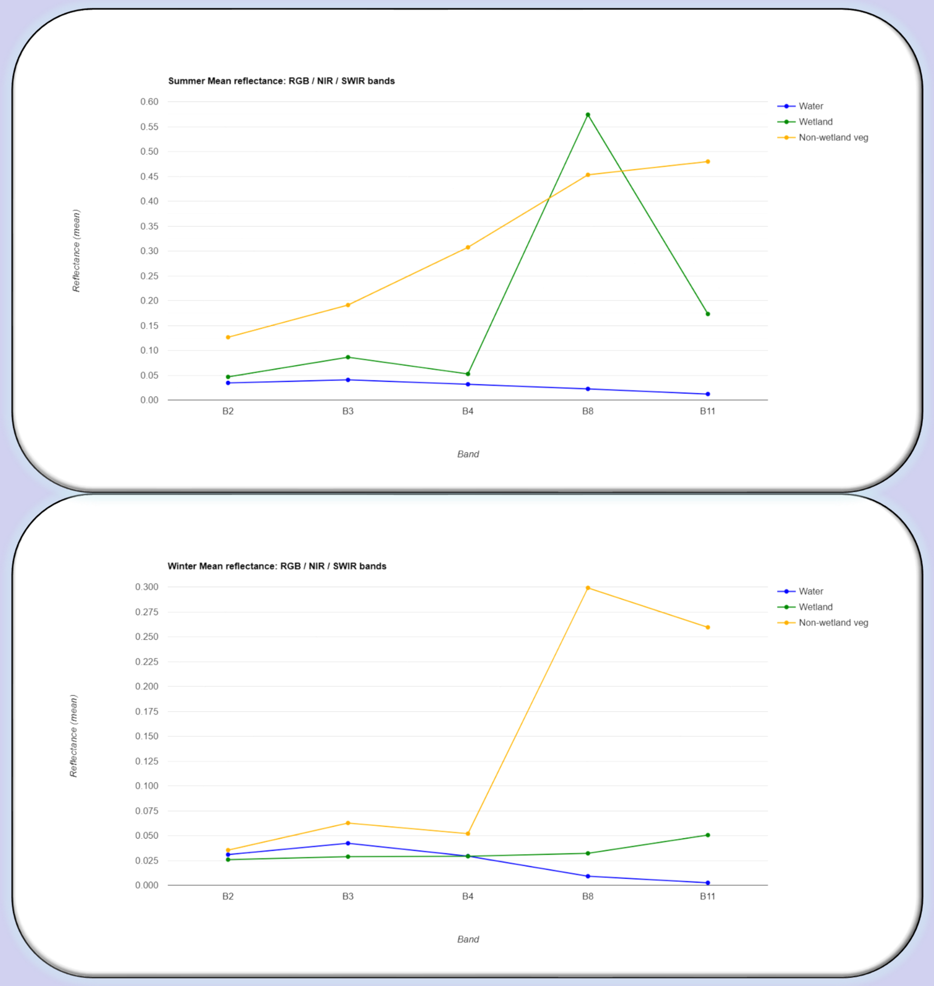

Figure 3. Spectral Signature Graphs (Summer vs Winter) Wetland vegetation shows an increase in decrease in B11 reflectance during Winter due to factors like seasonal inundation Additionally, B8 reflectance is much higher in summer due to the seasonal drying of wetland areas

Permanent water, exhibits consistently low reflectance across all bands, especially in B8 and B11, due to strong absorption of both NIR and SWIR by water. **Unlike wetlands**, it lacks seasonal vegetation dynamics, so its spectral signature remains flat year-round.

Using **NDMI maps for all four seasons** *(Fig. 4)* helps show how wetlands change through the year. In spring and winter, wetlands get wetter from precipitation and seasonal flooding, which raises NDMI values. In summer and fall, they dry out—plants lose moisture, water levels drop, and NDMI goes down. Areas near permanent water stay moist longer, but many wetlands go through clear **wet and dry phases**. These seasonal changes help us see where flooding happens, how much moisture is in the soil and plants, and how wetland vegetation responds over time. This makes it easier to track water patterns and plan for land and habitat management.

In *Fig. 5*, a **change detection in NDMI** was conducted between Summer and Winter median composite imagery. The area circled within the map visualizes the seasonal flooding and moisture retention of northern Liberty Island. The vegetation in this area reflects less B11 during winter due to **increased surface** and canopy moisture. This decline in B11, coupled with reduced B8 reflectance from submerged vegetation, drives a more negative NDMI signal, indicating wetter conditions. The blue coloration in the map confirms this trend, highlighting areas where NDMI increased from summer to winter, consistent with seasonal inundation and water retention. These spectral shifts are ecologically significant: they mark zones of persistent winter flooding and potential habitat suitability for waterfowl and aquatic species. By comparing NDMI across seasons, we can distinguish dynamic wetland vegetation from permanent water bodies as well as upland areas, Helping track flooding, moisture levels, and how wetland plants respond over time in the Cache Slough Complex.

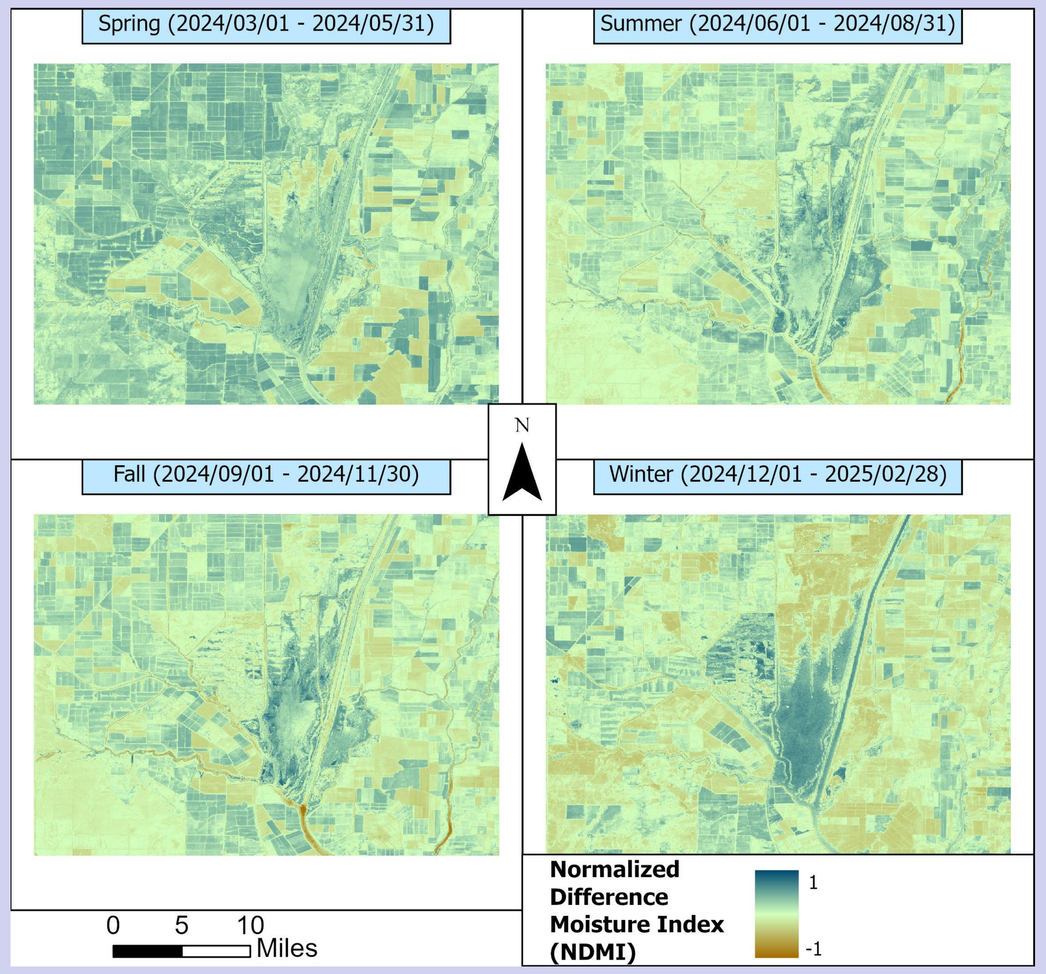

Figure 4. Seasonal composites in NDMI

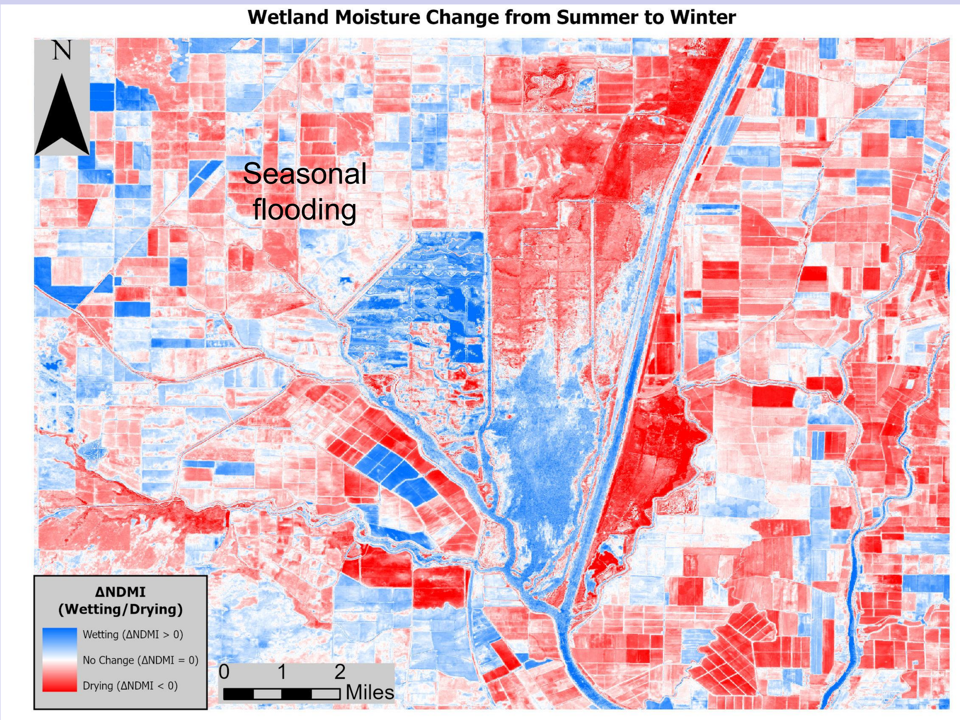

Figure 5. Change Detection in NDMI between Summer and Winter

2. Methodology

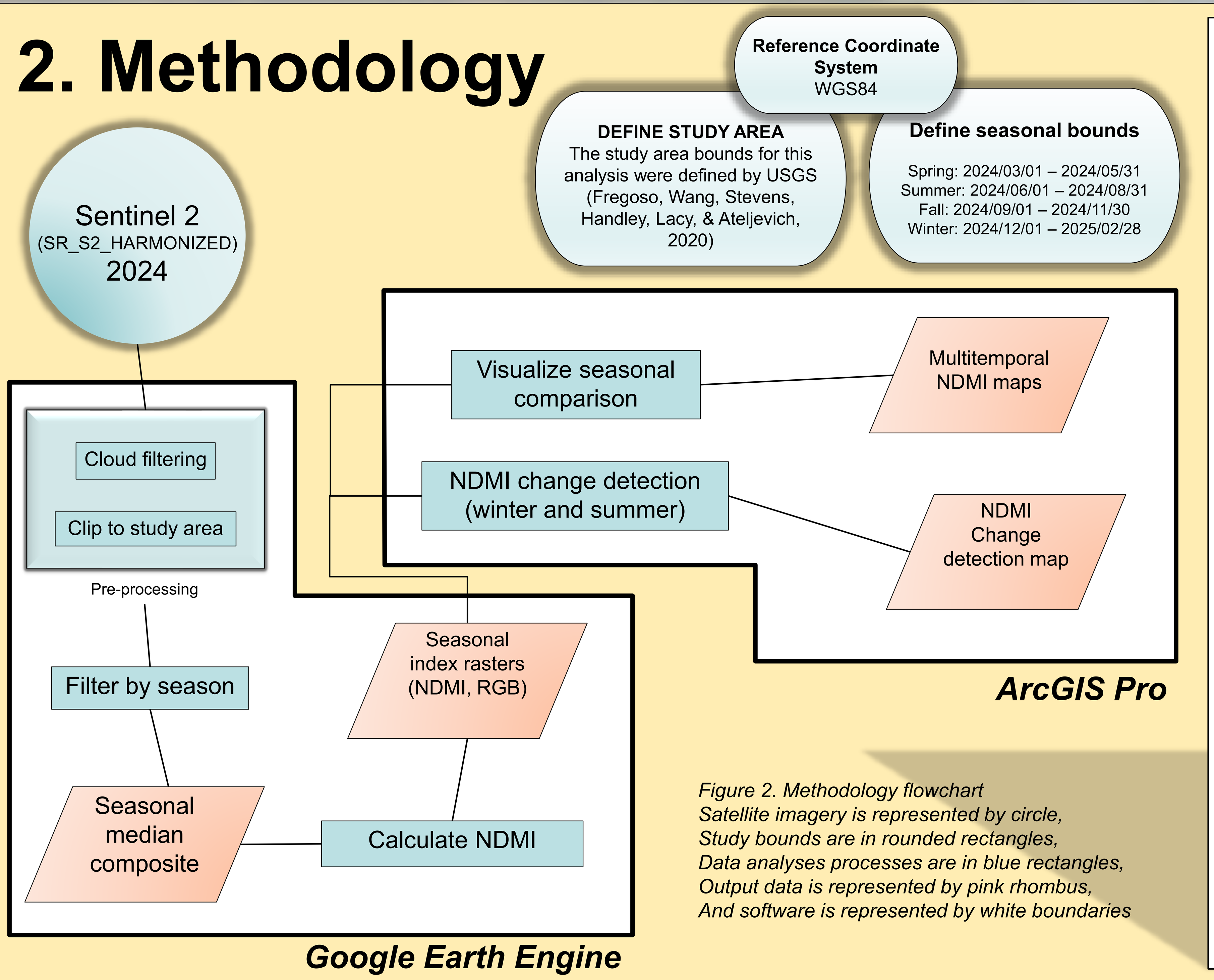

Figure 2. Methodology flowchart
Satellite imagery is represented by circle,
Study bounds are in rounded rectangles,
Data analyses processes are in blue rectangles,
Output data is represented by pink rhombus,
And software is represented by white boundaries

In *Fig 1.* of the **Cache Slough Complex**, the shape of the wetland area appears in contrast to the rigid plots of land surrounding. A river network protrudes from a central body of water, and upon closer look the texture of vegetation can be seen on the fringes of the water. Wetland vegetation habitats are complex and dynamic, spending significant amounts of time switching between being a flooded or dry environment, depending on the time of year. By using multitemporal analysis of multiple seasons from **Sentinel-2 (S2_SR_HARMONIZED)** imagery on a five-day temporal resolution, seasonal changes in vegetation and moisture can be monitored. Remote sensing also provides information via spectral bands B2,B3,B4,B8,B11, which allow for measurable spectral indices like **Normalized Difference Moisture Index (NDMI)** that inform vegetation health and moisture content which cannot be seen through normal RGB imagery. Sentinel-2 imagery is a 10m resolution, which is detailed enough to differentiate between the variety found in wetland habitats. This project aims to utilize the analyses of multitemporal NDVI and NDMI indices, as well as a NDMI change detection between two seasons, to better visualize the unique dynamics found in wetlands. *Fig. 2* outlines the methodology used, as well as the software used to process data (**Google Earth Engine and ArcGIS Pro**).

4. Discussion & Conclusion

Remote sensing allows for the analysis of seasonal patterns of wetland moisture and vegetation greenness in the Cache Slough Creek by using NDMI and change detection to visualize trends. NDMI highlights seasonal cycles and distinguished dynamic wetland vegetation from permanent water and upland areas.

Moving forward, using NDMI accompanied with field survey data could allow for a supervised classification of wetland land cover; by being able to cross-reference distinguished dynamic wetland areas with land survey data and digital elevation models, trusted land classifications can be trained. These analyses can help guide restoration projects of various wetlands across the state.

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