1. **Title:** Examining River Evolution: A historical analysis of riparian vegetation and channel morphology of the Platte River, Nebraska

2. **Principal investigators:**
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3. **Project title:** Examining River Evolution: A historical analysis of riparian vegetation and channel morphology of the Platte River, Nebraska
4. **Project Type:** Research
5. **Congressional District:** First congressional district of Nebraska
6. **WRRI Science Priorities:** Water Hazards and Climate Variability
7. **USGS Cross-Discipline Landscape and Science Descriptors**: Upper Mississippi and Hydrology
8. **Keywords:** Hydrology, geomorphological process, riparian vegetation, climate, drought, flow regulations, remote sensing, Landsat, land cover classification
9. **Training Potential:** This research will provide training to one undergraduate student. Training will be provided to students in remote sensing data analysis using cloud-based storage and the computational platform Google Earth Engine. The student will be involved in remote sensing data processing and, to a lesser degree, in data analysis. The student will also participate in the report writing process.

10. **Principal investigator(s):**
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11. **Start Date:** 09/01/2025
12. **End Date:** 08/31/2026

13. **Abstract:**

The Platte River, a highly managed tributary of the Missouri River, plays a crucial role in Nebraska's water resources. The river is vital for agricultural producers and industry, provides drinking water for the City of Lincoln and other communities, and is home to a plethora of wildlife such as the Sandhill Crane, piping plover, and the river otter. Over the past century, significant hydrological, ecological, and geomorphological changes have reshaped the river due to upstream diversions, dam regulations, and increasing groundwater withdrawals. These alterations have narrowed the once wide, braided Platte River while expanding the vegetated area, resulting in habitat loss for endangered species such as the whooping crane and piping plover. Furthermore, excessive water withdrawals have reduced base flows, further stressing the riparian ecosystem. This study aims to quantify long-term changes in riparian vegetation and channel morphology along the Platte River from 1984 to 2025. Using multi-spectral satellite

imagery from Landsat sensors processed in Google Earth Engine, the study will assess vegetation dynamics and channel changes through vegetation indices and land cover classification. The research will also integrate hydroclimatic data, including temperature, precipitation, and streamflow records, to estimate their influence on river morphology and vegetation patterns. By identifying long-term trends in vegetation encroachment and channel shifts, this study will provide critical insights for conservation and water resource management. The findings will help to inform adaptive management strategies for balancing ecological conservation with Nebraska's growing water demands. The results will support ongoing restoration efforts led by agencies such as the Platte River Recovery Implementation Program (PRRIP) and contribute to USGS river management goals.

14. **Plain-language summary:**

The Platte River in Nebraska has changed significantly over the past century due to human activities such as dam construction, groundwater use, and water diversions. Platte River has become narrower and overgrown with vegetation, reducing important habitats for endangered birds like the whooping crane due to reduced flows. These changes also affect water availability for irrigation, increase flood risks, and impact on local communities. This study will use satellite images to determine the changes in the river's shape and vegetation from 1984 to 2025. By analyzing climate data, streamflow, and land cover changes, the research will help us understand what drives these changes. The findings will provide important information for conservation groups and water managers to restore habitats and maintain the river's health while balancing Nebraska's water needs. This research will support efforts to protect the river and ensure a sustainable future for both people and wildlife.

Project Narrative

15. **Statement of State Water Problem**

The Platte River system, a major tributary to the Missouri River, is one of the highly managed rivers that flows through the heart of Nebraska. It serves as a critical source for drinking water, irrigation, wildlife habitat, and recreational and industrial uses. However, due to reduced flows from upstream diversions, dam regulations, and increasing groundwater withdrawals, the river faces hydrological, ecological, and geomorphological challenges. Over the past century, the Platte River has transformed from a wide, braided channel to a narrower, heavily vegetated floodplain, losing open sandbar habitat in some sections (Horn et al., 2012; Johnson, 1994). The sandbars and wetlands of the Platte River are home to endangered species such as the whooping crane and Pallid Sturgeon, and threatened species such as the piping plover (Horn et al., 2012). Additionally, excessive water withdrawal for irrigation has lowered the base flows, further stressing the aquatic and riparian ecosystem.

Despite the ongoing conservative efforts, the continuous long-term trend and drivers of these changes remain poorly understood. Previous research has focused more on hydrology and sediment transport (Joeckel et al., 2015), but few studies (Horn et al., 2012; Werbylo et al., 2017) have quantified multi-decadal vegetation changes and channel morphology shifts using remote sensing and evaluated the impacts of hydroclimatic variables on those changes. Although prior studies have analyzed hydrological changes and sediment transport mechanisms, limited research has integrated hydroclimatic drivers with remote sensing-based vegetation and channel

morphology assessments over a multi-decadal period. This study will bridge this knowledge gap by providing a long-term systematic evaluation of Platte River changes using machine learning approaches applied to satellite imagery. It will further build on previous findings by analyzing how key hydroclimatic factors, including streamflow regulation, precipitation variability, and temperature shifts, have influenced vegetation encroachment and channel narrowing. The advancement of remote sensing data provides an opportunity to systematically assess historical changes in riparian vegetation and channel morphology. By analyzing decades of satellite data using a machine learning approach, this study will examine how the river's shape and vegetation have changed over time, providing essential knowledge to guide conservation and management efforts.

Furthermore, this study will expand the scope by evaluating the effectiveness of past river management interventions, including environmental flow releases, sediment augmentation, and vegetation removal, in mitigating habitat degradation. This will allow a more comprehensive understanding of how human interventions and climate variability collectively influence riverine landscapes, offering critical insights for adaptive management strategies.

16. Statement of results and significance

a) Relevance and importance

The ecological transformations of the Platte River are not just an environmental concern; these changes pose economic and social risks by reducing water availability for irrigation, increasing flood hazards (Korus et al., 2024), diminishing recreational value and decreasing water for domestic and municipal use. If these environmental challenges remain unaddressed, the Platte River may continue to degrade, leading to a loss of essential habitats, reduced water availability, and increased management difficulties. This will threaten migratory birds such as the Sandhill Crane and also influence floodplain connectivity and groundwater recharge. With Nebraska's water demand continuing to rise and extreme droughts becoming more frequent, the need to quantify these long-term changes and their drivers have become more critical than ever.

b) Alignment with Priorities

This proposed study aligns with the key regional and national priorities for adaptive river management, habitat restoration, and water resources conservation. The research supports the goals of the USGS for river management and complements ongoing conservation efforts to restore the habitats and maintain the river by addressing sediment transport issues led by The Nature Conservancy, Platte River Recovery Implementation Program (PRRIP), and the Central Platte Natural Resources District (Traylor et al., 2023). PRRIP has performed numerous studies at different phases to monitor the changes in vegetation and channel morphology in response to river management efforts. Previous studies were performed using intensive field data collection techniques and remote sensing techniques, focusing on the reach between Lexington and Chapman (approximately 90 miles). By analyzing multidecadal historical assessments of riparian vegetation and channels along the Platte River in Nebraska, this study will provide critical

insights for managing vegetation encroachment and sediment transport issues. Moreover, our study will also improve our understanding of how climate variables, including streamflow changes, have impacted the vegetation and channel morphology over time, along with the river management efforts. It will also support the adaptive management plan of PRRIP to optimize water allocation for ecological restoration for balancing ecological conservation with Nebraska's growing water demands. Managers will also be able to assess the current locations of endangered species and leverage our findings to determine their preferred habitats. This insight will enable us to replicate these conditions at other sites along the Platte River.

c) Impact and scientific contributions

The findings from this research will have direct impacts on the restoration efforts, river management, and policy development of the Platte River in Nebraska. The results will inform the habitat restoration efforts by identifying critical locations of sediment deposition, splays, sediment erosion, and vegetation encroachment (Korus et al., 2024). The results of this study will provide a historical baseline of vegetation and channel morphology changes in response to past flood events, which can inform environmental flow studies focused on sediment flushing, native vegetation recruitment, and habitat maintenance for endangered species, key priorities for PRRIP.

This study will also provide critical data to guide ongoing management and conservation efforts, led by PRRIP, Central Platte Natural Resources District, and the Nature Conservancy, in managing instream flows, mitigating vegetation encroachment, and restoring essential habitats for endangered species like the whooping crane and piping plover. This research will help inform conservation strategies that balance ecological restoration with increasing water demands by quantifying multi-decadal trends in channel morphology and riparian vegetation changes. Additionally, policymakers can use these findings to refine water allocation policies and sediment management strategies in collaboration with PRRIP and other regional stakeholders.

To strengthen the link between research and management, this study will evaluate historical river changes with documented management interventions over the 40-year timeline. By integrating hydroclimatic data with land cover and channel morphology changes, we will evaluate whether past strategies, such as flow regulation, sediment augmentation, and vegetation removal, have successfully mitigated channel narrowing and habitat loss. Furthermore, we will also analyze how streamflow changes resulting from river management efforts, including environmental flow releases and water diversions for irrigation, have shaped hydrologic and geomorphic processes over time. These insights will provide a science-based foundation for future conservation and restoration planning.

This project will be completed in partnership with the PRRIP. PRRIP has offered to share the training datasets to support the machine learning model, along with the datasets that have been collected to monitor the changes in the river system.

We will share the study findings as a write-up report, peer-reviewed publications, and conference to ensure the research directly informs decision-making processes.

d) Extramural Proposal

The study performed here will be instrumental in applying for nationally competitive grants, including the National Science Foundation (NSF), especially for the Hydrological Science program. This research will provide a baseline for conducting an environmental or ecological flow study along the Platte River. The proposed project also aligns with the U.S. Geological Survey (USGS) 104(g) program in evaluating extreme hydrological events for the conservation of the ecosystem. The report will also be provided to the Department of Natural Resources of Nebraska, which is also part of PRRIP for restoring endangered species.

17. **Proposed objectives of the project and timelines**

The proposed research goal is to provide information that aids in the support of the river management goals of USGS in understanding the response of the Platte River system to the hydroclimate variables (precipitation, temperature, and changes in the stream flow regulated by dams, and diversion canals) to restore the endangered species, management of riparian vegetation and maintenance of river considering the sediment transport issues.

Hence, the primary objectives of this study are to:

1) determine the trend in changes in riparian vegetation and channel morphology of the Platte River from the confluence of the North and South Platte to the confluence of the Platte and Missouri River from 1984 to 2025
2) analyze the effect of hydroclimatic variables on changes in riparian vegetation channel morphology of the Platte River

The proposed project will be completed in 12 months (Table 1). The first part of the project is the preprocessing of satellite images to determine the trend of riparian vegetation and channel morphology along the Platte River. The second part will be determining the impact of changes in stream flows and the climate variables on riparian vegetation and channel morphology.

Table 1: Project timelines

Major Task	**Project Month**					
	1-2	**3-4**	**4-6**	**7-8**	**9-10**	**10-12**
Objective 1						
Process Landsat imagery in GEE						
Classify land cover						
Outcomes: Determine the temporal trend in vegetation and channel morphology						
Objective 2						

Collect streamflow and weather station data						
Outcomes: Determine the relation between hydroclimatic variables, vegetation change, and channel morphology						
Analyze the results						
Deliverables						
Write-up report						
Develop publications						

18. Methods

To accomplish the proposed objectives, we will use the freely available multi-spectral and multi-temporal satellite imagery collected by Landsat sensors 5, 7, 8, and 9 from 1984 to 2025 and Sentinel-2 from 2015 to 2025 (not available prior to 2015) for the Platte River (Figure 1). The image processing will be performed in the Google Earth Engine (GEE), leveraging cloud-based storage and computational capabilities.

The hydrological regime of the Platte River varies along different sections due to several factors, including heavy diversions, areas with lower management emphasis, and groundwater dominance. We will perform the analysis based on the hydrological regime along the Platte River in Nebraska.

Temporal changes in vegetation will be assessed using vegetation indices such as the Normalized Difference Vegetation Index (NDVI). NDVI is widely used for determining the health and water stress levels in plants. Similarly, to determine the frequency of flooding or change in the pattern of river morphology, Normalized Difference Water Index (NDWI) will be used. The changes in vegetated areas and geomorphological features such as sandbars and splays will be quantified through land cover classification using a machine learning algorithm (Random Forest) in GEE. We will perform the land cover classification every 5 years to reflect the changes in land cover due to major environmental events such as extreme precipitation or floods. To improve the accuracy of land use classification, we will utilize existing training datasets provided by the PRRIP team. These training datasets are developed through extensive fieldwork and monitoring to train models that will ensure consistency with the assessment efforts of PRRIP. One challenge using Landsat imagery is the 30 m spectral resolution and the limitation in identifying smaller islands or sandbars, particularly upstream of the Loup confluence. Temporal trends in vegetation and channel morphology will be determined using the Mann-Kendall test.

Additionally, we will also collect the historical aerial imagery, which is available before 1930’s to extend the study to understand the historical behavior of the system. The results from remote sensing data analysis and machine learning methods will be verified based on the existing available datasets.

We will determine the impacts of hydroclimatic variables such as temperature changes, precipitation, and streamflow alterations on the changes in vegetation cover and the pattern and dimensions of the channel morphology. Historical precipitation and temperature data will be collected from the nearest weather stations, and streamflow data from USGS and DNR gaging stations. Some of the USGS gaging stations dated back to the 1900s, and weather stations dated back to the 1800s in the vicinity of the study area. This will allow us to determine the relationship between vegetation changes and channel morphology. The relationship between the hydroclimatic variables and changes in vegetation and channel morphology will be determined by using correlation analysis. To avoid the misinterpretation of trends in vegetation and channel morphology changes, we will incorporate data on in-channel vegetation management (e.g., phragmites removal). These efforts were initiated in 2008 and have significantly influenced vegetation cover. They must be accounted for when interpreting remote sensing results post-2000.

By integrating remote sensing with hydroclimatic data, this study will provide a comprehensive understanding of vegetation and geomorphological trends along the Platte River, informing future management strategies.

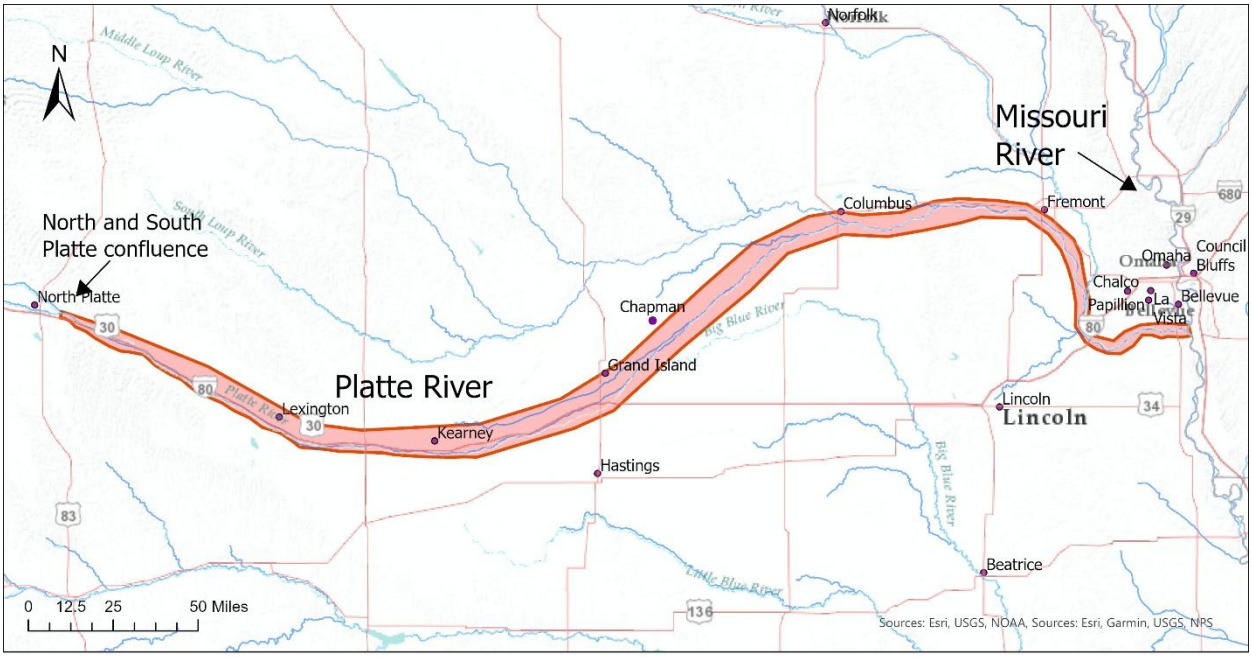

Figure 1: Platte River located in Nebraska, from where the North Platte and South Platte Rivers converge in the west to the confluence with the Missouri River east of Omaha.

19. Related Research

Remote sensing products such as Landsat, Sentinel-2, and LiDAR have been successfully used to study river systems (Langat et al, 2019; Chaulagain et al., 2024; Boothroyd et al., 2021). The application of remote sensing data provides a cost-effective, scalable, and temporally extensive

analysis of river system changes. In this study, we will apply the research framework and method that has been successfully implemented in the Rio Grande, a semi-arid region in the Southwestern United States, by Chaulagain et al. (2024), using remotely sensed data. In their study, they determined the trend in the riparian vegetation and channel morphology changes in relation to the hydroclimate variables by incorporating the impacts of prolonged drought in New Mexico. Rio Grande is also a sand-bed river similar to the Platte River. The hypothesis for the proposed study will be similar to the study of Chaulagain et al. (2024), in which vegetated areas will increase over time, with some native vegetation being replaced by non-native vegetation species and reduced channel width due to vegetation encroachment as a result of reduced streamflow.

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