Indiana's Herbaceous Wetlands

An Overview of the Effects of the Changing Climate on Herbaceous Wetland Ecosystems 2025

Introduction

Wetlands in Indiana are diverse ecosystems that can be found in every one of its 92 counties. The state is home to various wetland vegetation, including herbaceous, shrub-dominated, and forested. This document will focus on herbaceous wetlands, which include marshes, fens, bogs, and often areas around the margins of lakes or ponds and are categorized by emergent grass-like life forms, such as graminoids (Jr. Whitaker John O et al., 2012). Herbaceous wetlands are critical ecosystems for the survival of flora, fish, amphibians, reptiles, and birds.

This overview summarizes the expected climate projections and their impacts on Indiana's herbaceous wetland ecosystems over the upcoming decade. This document outlines expected changes to herbaceous wetlands and potential adaptation strategies to manage these ecosystems effectively. While this document is not a detailed report, it aims to provide stakeholders with a comprehensive understanding necessary for informed decision-making and effective wetland management in the face of the changing climate.

Key Climate Projections for Indiana

Warming Temperatures

Indiana's annual average temperature warmed 1.43°F from 1895 to 2022 based on a linear trend (MRCC, 2023). This warming trend is expected to continue and intensify into the foreseeable future (Widhalm et al., 2018). Average temperatures are expected to warm by 3°F above the long-term average by early-century (2011-2040) and 5°F to 6°F by mid-century (2041-2070).

Warming is expected in all seasons, with notable changes in the length and timing of seasons. **Indiana's winters will be shorter and warmer, specifically:**

- The average coldest winter night temperatures are expected to rise by about 6°F by mid-century, and the number of cold days (days when the daily minimum temperature is below 5°F) and frost days (days when the daily minimum temperature is below 32°F) will decline, particularly in northern Indiana.
- Rising temperatures will reduce the amount of winter precipitation falling as snow, and instances of snowfall of 2 inches or more will become less frequent.

Springs will come earlier, and summers will be much hotter in the future, specifically:

- The number of hot days (85°F to 95°F) and extremely hot days (above 95°F) will increase statewide, with the largest increases in the north, where mid-century projections show 24 to 25 more hot days annually compared to the past. In southern Indiana, hot days are expected to increase by 10 to 15 per year.
- The average length of heat stress events (consecutive days with high temperatures above 86°F) is expected to double by mid-century (Day et al., 2018).

Ongoing temperature increases will accelerate evapotranspiration rates (the amount of moisture lost to plant use and evaporation from surface soils and water) by 5-6% across Indiana by mid-century (Cherkauer et al., 2023).

Precipitation Variability

Indiana's annual precipitation has increased by 6.38 inches from 1895 to 2022 based on a linear trend (MRCC, 2023). Annual precipitation is projected to increase by 2-3% above the long-term average by early-century (2011-2040) and by 6-8% by mid-century (2041-2070) (Widhalm et al., 2018). Historical observations show that extreme precipitation events are becoming more frequent and intense in Indiana (Marvel et al., 2023).

However, those changes will not be evenly distributed throughout the year.
Precipitation will increase in winter and spring with slight declines or no change in summer and fall, specifically:

- Winter and spring precipitation is expected to increase 4-10% by the early century and 13-20% by the mid-century (Hamlet et al., 2020). Conversely, summer and fall precipitation changes are less certain, with early-century projections showing modest 1-4% declines in summer and fall precipitation and 2-3% declines by mid-century.

Seasonal temperatures and precipitation changes are expected to impact snowfall, snow cover, frozen soils, and evaporation rates. **Indiana winters are projected to be generally less snowy, and summers will have increased evaporation rates, specifically**:

- Rain is projected to replace much snow during the cold season (November to March). The percentage of cold-season precipitation falling as snow is expected to decrease significantly throughout the state. In southern Indiana, there will be little snowfall by the late century under both emission scenarios. Instances of more than 2 inches of snow will be quite rare in southern Indiana by the 2080s under the high emission scenario. In northern Indiana, snowfall will be greatly reduced compared to the past. Throughout the state, snow events greater than 2 inches are expected to happen about half as often by the end of the century (Widhalm et al., 2018).
- The number of days with frozen soil per year is projected to drop by half or up to two-thirds by the late century (Phillips et al., 2018).

Potential Implications of the Changing Climate on Indiana's Herbaceous Wetlands

The prevalence of current wetlands in the Midwest region depends primarily on climate conditions (Garris et al., 2015). Temperature increases and changing precipitation patterns can have complex and variable impacts on herbaceous wetlands, affecting their biogeochemical processes, carbon sequestration, primary productivity, community composition, and overall ecological functioning. The specific consequences will depend on local conditions and the interaction of these climate stressors with other factors affecting these wetland ecosystems.

Warming Temperatures

Temperature-sensitive biogeochemical processes are expected to increase due to warming soil temperatures. Elevated temperatures accelerate nutrient cycling and rates of decomposition and respiration in herbaceous wetland soils, reducing the ability of these ecosystems to sequester carbon effectively. This could increase carbon and methane emissions and threaten the role of wetlands as carbon sinks (Salimi et al., 2021).

Warming temperatures will likely cause shifts in community compositions in herbaceous wetland ecosystems. Increasing temperatures, including prolonged growing seasons, may lead to shifts in plant community compositions within wetlands. Vascular plants may become more dominant, displacing species like sphagnum moss, a dominant component of certain bogs found in northern Indiana. These shifts can alter the structure and diversity of wetland ecosystems (Salimi et al., 2021). However, the current distribution of this type of wetland is limited in Indiana.

Also, drought conditions resulting from increased temperatures may reduce the period of time in which wetlands hold water, decreasing the primary productivity in herbaceous wetlands (Salimi et al., 2021) and impacting plant life cycles and phenology (the timing of key life cycle events) (Hook et al., 2020). Thus, the **health and ecological functioning of herbaceous wetlands will likely decline due to increasing temperatures**.

Note: *It is important to consider that the impact of higher temperatures on herbaceous wetlands can vary depending on the specific wetland, local conditions, and the simultaneous presence of other stressors, such as drought.*

Warming temperatures will likely worsen the impacts of invasive species. Enhanced drying due to temperature changes may intensify the threat of invasive species like common reed (*Phragmites australis)* (Hook et al., 2020) and exacerbate the dominance of invasive species like reed canary grass (*Phalaris arundinacea*) in the Midwest, where invasive species are already a concern (Joyce et al., 2016).

Rainfall Variability

More variable precipitation patterns, including droughts, are potential stressors that can imperil herbaceous wetland systems in Indiana. Variability in precipitation and extreme rainfall events can lead to the loss of ephemeral wetlands, more ephemeral hydroperiods (the duration of time a wetland holds water) in semi-permanent wetlands, decreased species diversity, alterations in plant community composition, and the conversion of wetlands into terrestrial systems (Hook et al., 2020). Precipitation variability will stress wetlands in some situations, and in others, it may expand suitable areas for wetland establishment. However, wetlands are historically constrained by human land use, which will hinder how much new wetland habitat emerges (Garris et al., 2015). Additionally, shifts in flooding regimes due to variable rainfall can threaten wetlands and their ecosystem services, such as runoff and flooding attenuation, water filtration, and aquifer recharging (Joyce et al., 2016).

More variable precipitation patterns may decrease long-term soil moisture in herbaceous wetlands, affecting the overall health and composition of wetland ecosystems. Climate-induced shifts in hydrology (such as decreased soil moisture), as influenced by intermittent and infrequent precipitation events, can directly affect the distribution and resilience of wetland types, with some wetlands being more sensitive (Garris et al., 2015). Reduced soil moisture can reduce plant biomass in herbaceous wetlands, impacting the vegetation composition (Didiano et al., 2018).

The timing and frequency of precipitation events play a crucial role in determining the composition of herbaceous wetlands. Short periods without precipitation, even without prolonged droughts, can negatively influence wetland plant growth and lead to dominant vegetation structure shifts. Decreased water availability caused by infrequent precipitation events has been shown to cause soil moisture stress, disproportionately affecting key component species of wetlands and potentially leading to shifts in species dominance and community composition within herbaceous wetlands (Didiano et al., 2018).

Enhanced drying due to changing rainfall patterns can intensify the threat of invasive species in herbaceous wetlands. Variable precipitation increases the risk of further invasion of invasive species, such as common reed (*Phragmites australis*), in Indiana's wetlands (Hook et al ., 2020).

Levels of Uncertainty

Understanding the impact of the changing climate on wetland ecosystems, as highlighted by conflicting evidence on rainfall changes (Salimi et al., 2021), is a complex task. This complexity arises from the diversity of wetland types, geographic locations, and the interaction of various stressors. For example, the relationship between rising temperatures and soil biogeochemical processes in herbaceous wetlands is intricate, influenced by factors like plant growth, soil aeration, and local conditions, making it difficult to make precise predictions. Uncertainties also extend to climate projections and the potential for unexpected vegetation responses, which

might need to be fully accounted for in current models. **However, uncertainty does not mean that the effects of climate stressors on herbaceous wetland ecosystems are unknown.** The goal is to consider these uncertainties when responding to the changing climate by implementing proactive measures, adaptable strategies, and preparation to ensure the resilience of wetland ecosystems in the face of an uncertain climate future.

Management and Adaptation Strategies

Based on the literature reviewed, the following strategies have been proposed as potential actions to ensure the optimal health of herbaceous wetland ecosystems in Indiana and can be adapted in the future.

- **Research**: There is a need for a deep understanding of how warming temperatures interact with other factors, such as vegetation composition, to guide effective management strategies for maintaining desired wetland conditions. This will help guide potential restoration efforts.
- **Invasive Species Management**: As there are changes in the region's climate, it is likely to cause increased occurrences of invasive species in wetland habitats. Mitigation mechanisms and management of the spread of invasive species, such as common reed (*Phragmites australis*), will be crucial (Hook et al., 2020).
- **Monitoring**: Monitoring and managing ephemeral wetland systems for potential climate-related stresses can potentially prevent drying and habitat loss (Hook et al., 2020).

Conclusion

In summary, the anticipated impacts of the changing climate on Indiana's wetlands reveal a complex and multifaceted future for these ecosystems. Rising temperatures and shifting precipitation patterns are set to disrupt the delicate balance of wetland processes, affecting various facets from species composition to biogeochemical processes. While some species may display resilience, invasive species, altered hydrology, and intensified disturbances pose significant challenges. Thus, it is essential to consider these potential modifications and inherent resiliencies while planning future strategies focused on herbaceous wetland ecosystems.

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