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Environmental Factors Influencing Diversity and Stability in Wetland and Lotic Plant Communities

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Abstract: *The health of freshwater ecosystems is seriously threatened by the shrinking and decreasing diversity of their habitats. Freshwater ecosystems come in a wide diversity and function well. In addition to contributing to this diversity, aquatic plants benefit the ecosystem and stabilize the community. The study's findings highlight the significance of functional variety in relation to ecological resilience by clarifying the effects of management strategies and climate change on aquatic plant communities. The importance of macrophytes and epiphytic algae in shallow lakes has been demonstrated by numerous noteworthy research. It is crucial to consider the impact of human activities on the environment while planning restoration projects. Smaller bodies of water should receive more attention when it comes to conservation initiatives. Additionally, you should consider factors like the depth of the water and the brightness of the light. Where macrophytes develop and how communities evolve over time are significantly influenced by these characteristics.*

Keywords: Macrophytes, Community stability, Wetland ecosystems, Lotic ecosystems, Climate change, Anthropogenic pressures

I. INTRODUCTION

Freshwater environments are small yet feature a lot of different kinds of plants and animals (Dudgeon *et al.,* 2006). These are rapidly losing biodiversity and space (Zelnik and Germ, 2023). Biodiversity enhances community stability and environmental factors in various ways (Downing *et al.,* 2014). Aquatic plants influence the functionality of rivers, lakes, and wetlands (Zhou *et al.,* 2023). The papers under the Research Topic talk about these problems. Their research elucidates freshwater ecosystem responses to environmental variables at various scales, the impacts of management and climate change on aquatic plant communities, and the diversity, stability, conservation, and biological control of invasive species.

Yang et al. (2023) given temporal niche partition and features trade off hypothesis, that were important ideas. Most niche-partitioned species pairings occurred in spring and fall. Functional diversity, which is resistant to environmental changes, gives better quantitative information about macrophyte ecology than taxonomy (Dalla Vecchia *et al.,* 2020). Stefanidis et al. assessed the functional diversity of aquatic plant communities in Greek rivers and examined ecological parameters to emphasize their significance in freshwater monitoring and conservation. Light choice and growth forms accounted for the majority of functional composition variance. Fine substrate systems and deep waters with little flow had more functional richness. Klančnik *et al.* (2015) found that epiphytic diatoms protect submerged *Potamogeton perfoliatus* leaves from short-wave radiation. Community dynamics' spatiotemporal flexibility influences cohabitation, boosting biodiversity in changing environments (Hallett *et al.,* 2023). Xing et al. evaluated the spatiotemporal fluctuations in average wetland Normalised Difference Vegetation Index (NDVI) during the yearly growing season in the Amur River watershed over four decades to determine climate change responses. Wetland NDVI is expected to rise with climate change, reducing plant community diversity. NDVI is useful for assessing wetland vegetation vigor and dispersion (Ojdanič *et al.,* 2025).

Anthropogenic influences and other factors affect aquatic plant community structure and diversity, which should be considered in restoration planning. Ponds and ditches have higher macrophyte diversity than rushing waters (Svitok *et*

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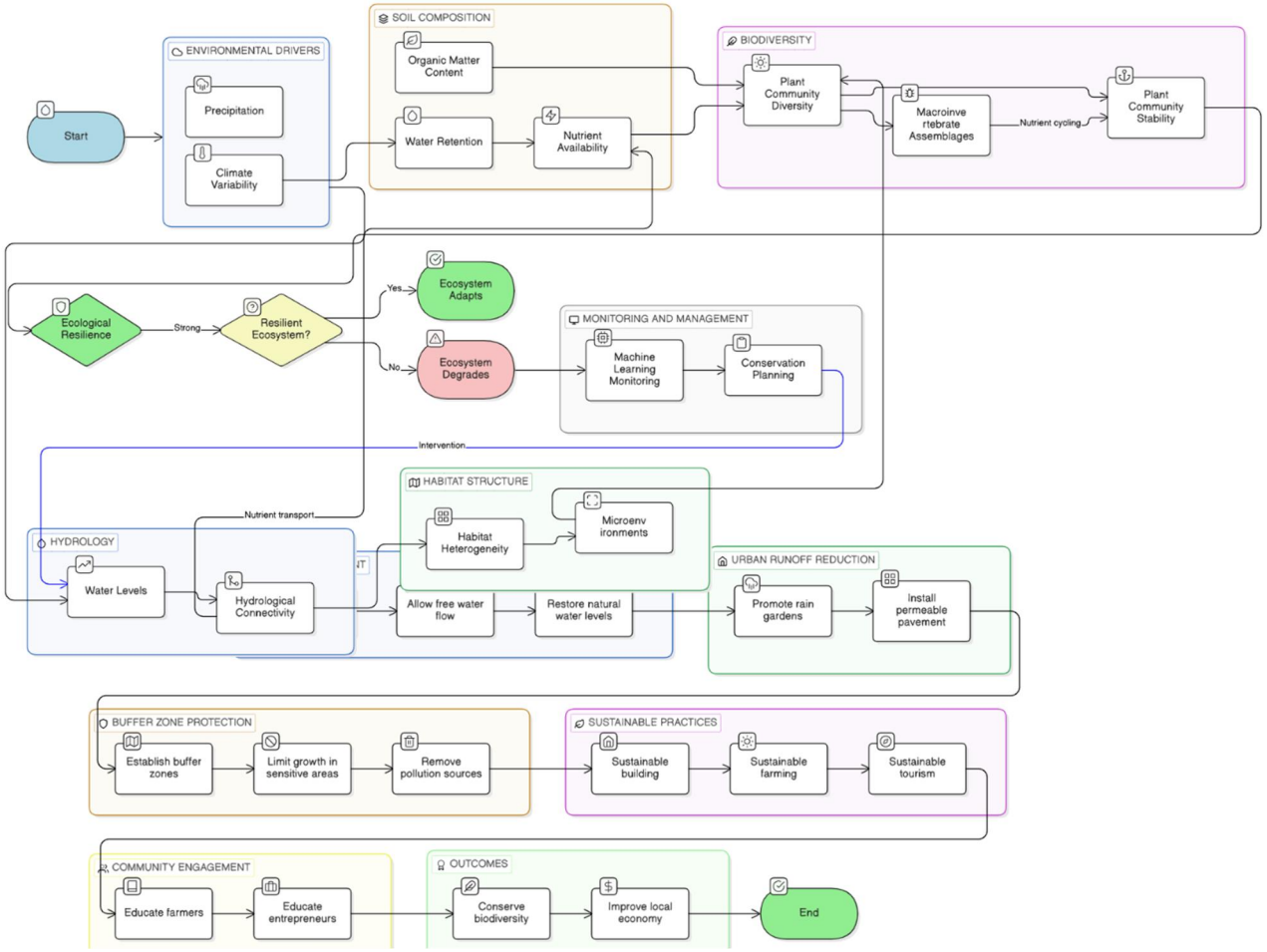
al. 2023) in Central Europe. Artificial habitats are valuable conservation assets, and tiny waterbodies should be prioritized in conservation programs. Light conditions affect macrophyte distribution (Liu *et al.,* 2016), and water depth is the strongest predictor of nutritional threshold of submerged macrophytes collapse and rebound in lakes, combining with turbidity. The canopy-forming submerged macrophyte Myriophyllum spicatum was more resistant to high nutrients and turbidity, although species richness was negatively affected by water depth. These findings may help quantify lake restoration of various depths.



Flow chart: Wetland and Lotic Ecosystem Resilience

II. LITERATURE REVIEW

Wetlands and lotic ecosystems play crucial roles in supporting diverse plant communities. Factors such as hydrology, soil composition, and nutrient availability significantly impact plant diversity and stability in these environments. Understanding these relationships is vital for ecological conservation and restoration efforts.

Hydrology is a key factor influencing plant communities in wetland ecosystems. Water levels impact which plants may grow in certain places. Li *et al.* (2022) studied ecological restoration in the Lancang River source region and found that hydrology and environmental factors affected plant diversity and stability. Magee and Kentula (2005) also showed how wetland plants adapt to hydrological changes. Their research indicated that water levels can modify plant composition, affecting community stability. Nutrient availability shapes plant communities too. Eutrophication, frequently caused by humans, disrupts plant diversity with surplus nutrients. Ansari *et al.* (2010) explored aquatic plant diversity in eutrophic

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settings and found that nutrient overload favored particular species, lowering variety. This imbalance can affect plant community resilience, which is crucial for ecosystem stability (Carvalho *et al.,* 2013).

Another important issue is soil makeup. Different soil types sustain different plant species, creating diverse communities. Gaberščik, Krek, and Zelnik (2018) found that habitat diversity in wetlands along a hydrological gradient promotes plant species diversity. This shows that soil texture and nutrient concentration affect which plants can grow in these habitats. Li et al. (2014) noted that plant diversity can indicate vegetation stability in plateau wetlands, where soil parameters strongly influence both.

Plant communities are complicated due to hydrological, soil, and nutrient interactions. Multiple paths sustain wetland plant communities along an elevation gradient, Fu *et al.* (2019) observed. Hydrological conditions and nutrient levels interact with soil composition to maintain community resilience, according to their study. Hydrological connectedness affects soil moisture and nutrient distribution, hence Reid, Reid, and Thoms (2016) stressed its importance for floodplain river plant communities.

Freshwater rivers and streams are lotic ecosystems with unique factor relations. Winemiller *et al.* (2010) found that environmental variability affects lotic patch dynamics and plant diversification. Hydrological patterns provide microhabitats for many plant species, increasing biodiversity, according to their findings. Hydrology greatly affected plant and invertebrate community structure and stability in headwater wetlands, according to Drinkard *et al.* (2011). Regional research has produced many case studies. Hudson *et al.* (2006) predicted low-water plant responses in the Lake Ontario-St. Lawrence River basin. This revealed how crucial it is to balance management and plant variety. They found that healthy wetland plant communities need water management. Bayley and Guimond (2008) examined how river connection impacts marsh vegetation in Canada and stressed the importance of water flow in maintaining montane floodplain wetland plant groups. Environmental factors affect plant diversity and macroinvertebrate numbers. Mereta *et al.* (2012) examined how conditions affected Ethiopian natural wetlands macroinvertebrate numbers and diversity. Hydrology, soil, and nutrient availability are linked, and a diversified plant community increases species diversity. Finally, water cycle, soil type, and nutrient availability affect plant community diversity and stability in wetlands and lotic habitats. Case studies show how these aspects interact and affect each other. Understanding these processes is crucial to protecting and restoring these ecosystems since disruptions can reduce plant variety and stability (Li *et al.,* 2022; Gopal, 2009). Research reveals that healthy wetlands and river systems boost biodiversity and ecosystem resilience.

III. DISCUSSION

Wetlands and lotic ecosystems are complex networks where hydrology, soil composition, and climate fluctuation affect plant diversity and stability. Ecological resilience—the ability of ecosystems to adapt to environmental changes—depends on these interrelationships. Plant growth depends on hydrology, which is mostly determined by precipitation and soil water retention. Li *et al.* (2022) found that environmental factors controlled plant diversity and stability in the Lancang River source basin, underlining the importance of hydrological dynamics in plant community structure.

Another important aspect impacting plant communities is soil composition. Different soil types have different nutrient, water retention, and pH levels, which affect plant species composition. Wetlands with high organic matter concentration typically have more diversified and stable plant communities (Gaberščik *et al.,* 2018). Li *et al.* (2022) demonstrated that water levels regulate plant community structures in ombrotrophic bogs, showing how hydrology and soil affect vegetative biodiversity.

Climate variability complicates ecosystems. Temperature and precipitation changes can substantially alter hydrological regimes and soil moisture content, affecting plant diversification. Fu *et al.* (2019) found that wetland plant communities may retain stability through numerous ecological pathways despite gradient changes like elevation, demonstrating their resilience. Zheng *et al.* (2019) showed how climate variability affects plant community composition in the Tumen River Basin wetland plants. The interaction between hydrological connectivity and soil composition stresses their relevance in ecological resilience. Reid *et al.* (2016) say that hydrological connection in floodplain systems lets nutrients move across plants, which helps diverse plant groups. The way these nutrients are used changes based on the soil composition, which

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creates a dynamic interaction that promotes both diversity and stability. Along with soil and water, having a variety of habitats along hydrological gradients is also very important for keeping plant communities diversified (Gaberščik *et al.,* 2018). There are several microenvironments with different types of plants in marshes, swamps, and along riverbanks. Ecological resilience increases and plant life persists because various species react differently to stressors. Bolpagni and Piotti (2016) observed that wetlands increase habitat heterogeneity and plant functional diversity. Lotic ecosystems rely on macroinvertebrate assemblages influenced by hydrology and plant diversity. Bush *et al.* (2019) discovered that beaver-created successional gradients enhance invertebrate diversity, hence improving habitat structure and nutrient cycling, which indirectly benefits plant communities. This shows how species in these ecosystems are connected, which means that changes in one can affect the others.

New advances in ecological monitoring methods help us comprehend these complex connections better. Feng *et al.* (2024) say that machine learning algorithms can keep track of changes in wetland plant communities throughout time and space. Technological improvements may help ecological managers figure out how plant communities will alter because of climate and water changes. The enduring relationship among hydrology, soil composition, and biodiversity renders wetland and lotic ecosystems resilient to climate change and anthropogenic influences. Sharma and Naik (2024) say that each part of these systems works together to make them work. Matias *et al.* (2021) assert that aquatic plants can endure in ostensibly inhospitable environments, illustrating nature's persistence. In conclusion, hydrology, soil composition, and climate variability influence plant community diversity and stability in wetlands and lotic ecosystems, maintaining a fragile equilibrium. The interconnections help ecosystems stay strong and guide conservation efforts. As we continue to learn more, we begin to appreciate these ecosystems more and more because they protect us from climate change and environmental degradation. After reviewing the work of Ismail *et al.* (2018) and Stefanidis *et al.* (2023), we must continue to learn more about these connections so that we can devise a plan to protect our environment.

IV. CONCLUSION

Despite their relatively small size, freshwater ecosystems are crucial to biodiversity and are drastically declining. Because they greatly affect both variety and functionality, aquatic plants are crucial to these systems. In this research, several factors that affect freshwater plants are examined. These elements include the impact of human pressures, functional variety, and environmental variables. The most significant results imply that plant communities and their stability are influenced by hydrology, soil composition, and nutrient availability. Understanding these dynamics is essential for effective conservation and restoration efforts that support biodiversity and ecosystem resilience throughout wetland and lotic.

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