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RESEARCH

Effects of flood frequency and bank types on plant species composition in riparian wetlands

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Background: This study investigates the impact of flooding rate and bank type on plant species composition in riparian wetlands. Riparian wetlands, which are connected to rivers, provide a unique ecological environment shaped by periodic flooding and water flow, supporting diverse flora and fauna. The flooding rate directly influences plant community structure; flood-tolerant species dominate frequently flooded areas, whereas other species thrive in less frequently flooded zones. Bank type affects soil moisture distribution, influencing plant composition and growth. Soil characteristics were analyzed, and vegetation was surveyed across the upper, middle, and lower sections of banks at 30 sites along the Han River in Korea.
Results: The study found that the upper sections of banks where water flows down from the land maintained higher soil moisture content, favoring the dominance of moisture-tolerant species such as *Phragmites australis* and *Humulus japonicus*, which consequently reduced species diversity. In contrast, the upper sections of banks with levees that restricted water flow exhibited relatively lower soil moisture content, reducing the prevalence of dominant species such as *H. japonicus* and *P. australis* and thereby promoting higher species diversity. Most environmental factors showed no significant differences between the two bank types, except for soil moisture content in the upper section and soil organic matter content and pH in the lower section, which exhibited statistically significant variations ($p < 0.05$). Soil moisture content, pH, soil organic content, and soil texture were identified through redundancy analysis as key environmental variables influencing plant distribution, with each species responding uniquely to the hydrological and soil conditions shaped by flooding rate and bank type.
Conclusions: This study highlights the need for effective levee design and wetland management strategies to promote biodiversity and maintain ecological balance in floodplain ecosystems.

Keywords: bank type, flooding rate, riparian wetlands, species diversity

Introduction

Riparian wetlands, which are connected to rivers, provide a unique ecological environment shaped by periodic flooding and water flow (Junk et al. 1989; Kim et al. 2025). These conditions create an environment where water can flow freely, allowing diverse flora and fauna to thrive (Tockner and Stanford 2002). Riparian wetlands play an essential role in maintaining ecosystem diversity, as new nutrients are introduced and sediments are redistributed during floods (Middleton 1999). For this reason, riparian wetlands exhibit higher biodiversity than other wetland types, providing habitats for various species adapted to both aquatic and terrestrial ecosystems (Ward et al. 1999).

The rate of flooding directly influences plant species composition in riparian wetlands (Naiman and Décamps 1997). Plant species composition is also largely determined by the presence or absence of levees in riparian wetlands (Johnson et al. 2016). In frequently flooded areas, certain plant species dominate due to prolonged inundation (Junk et al. 1989); for example, flood-tolerant plants capable of surviving in low-oxygen conditions thrive, while other species are outcompeted (Mitsch and Gosselink 2015). Conversely, in occasionally flooded areas, water recedes more quickly after temporary inundation, creating favorable conditions for a wider range of plant species (van der Valk 2012).

The physical structure of riverbanks also plays a crucial role in regulating hydrological connectivity between rivers and adjacent riparian wetlands.

Natural levees are low-elevation ridges that form along riverbanks due to the deposition of fine-grained sediments, such as silt and fine sand, when floodwaters lose velocity near the channel edge. These features develop gradually over time and act as transitional zones, enabling varying degrees of water infiltration during flooding events (Knox et al. 2022).

In contrast, artificial levees are human-constructed structures designed to prevent flood damage or stabilize river channels. They are typically composed of materials such as soil, concrete, or gravel and often feature straight, elevated cross-sectional profile that separates the river from adjacent floodplain areas. In some cases, these structures are paved or accompanied by maintenance roads, further limiting water exchange between the river and adjacent wetlands (Klasz et al. 2014).

Soil conditions such as moisture content, organic matter, pH, and nutrient availability play a crucial role in determining the distribution and competitiveness of plant species in riparian wetlands (Park et al. 2018). Because flooding frequency can indirectly influence plant composition by altering these soil properties, analyzing soil parameters helps us better understand the mechanisms by which flooding rate and bank type shape vegetation patterns (Chen et al. 2015). Therefore, soil characteristics were included as key environmental variables to test our hypothesis that hydrological and physical conditions together determine plant species composition in riparian wetlands (Burandt et al. 2023).

In Korea, riparian wetlands account for the largest proportion of wetland area, comprising 66.3% of the total wetland coverage (Korea Water Resources Corporation 1999). These ecosystems are efficiently managed through a network of water-level monitoring stations that provide real-time hydrological data. Rivers in Korea, which are generally short and have controlled flow, tend to have a high coefficient of flow fluctuation, with limited meandering due to channelization (Han et al. 2013). This means that water levels in rivers fluctuate significantly, especially during the summer rainy season (Joo et al. 1997). Such hydrological changes shape the composition of wetland plant communities (Korea Water Resources Corporation 1999). Riparian vegetation shows distinct patterns in Korea, with *Typha orientalis* and *Phragmites australis* near the lower section, *Artemisia selengensis* in the middle section, and *Humulus japonicus* near the upper section of the bank (Kwon et al. 2006; Lee et al. 2007). *Phragmites australis* is widely distributed throughout riparian wetlands due to its high flood tolerance and competitive advantage.

Therefore, understanding the relationship between flooding rate and bank type is essential for identifying the factors driving differences in vegetation composition and their implications for biodiversity and ecological health in riparian wetlands (Tockner et al. 2000). This study aims to analyze the effects of bank type on soil moisture and plant species composition in riparian wetlands.

Materials and Methods

Study area

The Han River is a major waterway traversing the highly urbanized Seoul metropolitan region, surrounded by dense residential, commercial, and industrial developments. Flow regulation in the Han River is controlled through a system of upstream dams, as well as weirs and sluice gates managed by the Han River Flood Control Office (Fig. S1; Ministry of the Environment 2023). These structures are used to moderate flow variation, particularly during the summer monsoon season (June to September), which accounts for over 60% of the annual rainfall. The study area features both natural and artificial levees. Artificial levees are especially common near urbanized sections of the river and are typically built to prevent flood damage and maintain channel stability. In contrast, natural levees–formed by sediment deposition during overbank flooding–are found in less developed segments and vary in permeability and connectivity to floodplains (Fig. 1).

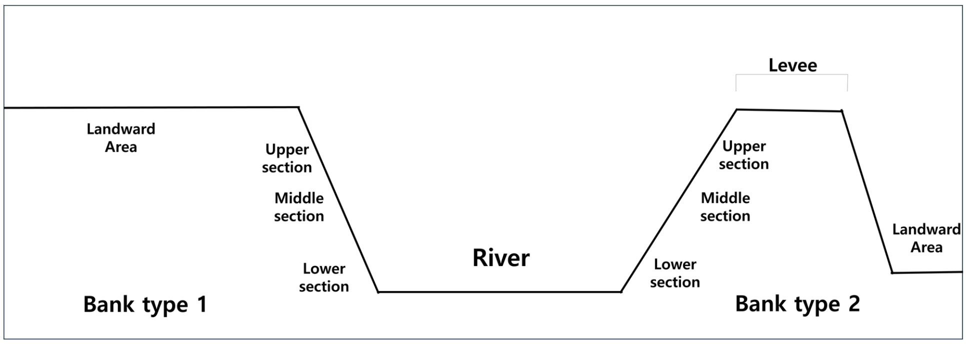

Fig. 1 Schematic diagram of bank types. Bank types are classified into two types: type 1, characterized by the absence of a levee, and type 2, defined by the presence of a levee. The area was divided into three sections: upper, middle, and lower. The measurement of linear distance from the upper boundary of the levee to the lowest point where vegetation occurred along the riverside and dividing this continuous distance into three segments.

Hydrological data was obtained from the Han River Flood Control Office, which is responsible for flood control and water resource management of the Han River, a major waterway traversing the Seoul metropolitan area (Ministry of the Environment 2023). Effective water management is essential for flood mitigation in this area. The Han River Flood Control Office collects water level measurements from 268 points along the Han River. For this study, 36 sites with consistent data from 2021 to 2023 were initially selected. However, due to accessibility issues such as military restrictions or physical obstacles like cliffs, six sites were excluded. The final study was conducted at 30 sites (Table S1).

The study area is characterized by a temperate climate, with long-term annual averages of approximately 11–12°C in temperature and 1,100–1,300 mm in precipitation, slightly exceeding global climatic averages (Korea Meteorological Administration 2021, 2022, 2023). During the survey period, observed climatic conditions were warmer and wetter than the historical average, with a mean annual temperature of 12.3°C and total precipitation reaching 1,440 mm.

Field survey

The specific study area was defined based on water gauges installed on-site by the Han River Flood Control Office. The study area extended 100 meters upstream from each gauge, encompassing both the left and right banks of the waterway. Field surveys were conducted from July to September 2023. Three transects, perpendicular to the direction of water flow, were established at 50-meter intervals along the centerline of the waterway. The line-intercept method was used to assess the coverage of individual species. For each species intersecting the three transects, the line length of the dominant plant species was measured, and the total line length of each species was divided by the total transect length to calculate the coverage.

Soil factors

All soil samples were collected simultaneously across all sites to minimize variation, and sampling was conducted under dry conditions to ensure that measurements were not influenced by recent rainfall. To analyze soil factors, samples were collected along the centerline at three points: near the upper section of the bank (90% of the total length), the middle section (45% of the total length), and the lower section near the water body (10% of the total length). The samples were then transported to the laboratory. Soil samples were sieved through a 2-mm mesh (standard sieve #10) to remove small plant particles and gravel. Soil moisture content (SMC) was measured by drying the samples in an oven at 105°C for over 48 hours (Kim et al. 2004). Soil organic matter content (SOC) was assessed using the loss-on-ignition method by heating the samples at 550°C in a muffle furnace for 4 hours (Choi et al. 2021; John 2004). To measure pH and electrical conductivity (EC), soil samples were mixed with distilled water at a 1:5 ratio (w/w) and filtered through Whatman filter paper #42 (Sigma-Aldrich, St. Louis, MO, USA). The pH and conductivity of the filtrate were measured using a pH meter (portable AP63 meter; Accumet, Devens, MA, USA) and a conductivity meter (model Starter 300C; OHAUS, Parsippany, NJ, USA). Total nitrogen (T-N) was measured using the Kjeldahl method (Bradstreet 1954), and total phosphorus (T-P) was measured using the perchloric acid digestion method (Sommers and Nelson 1972) at a chemical analysis company, the Cheil Analysis Center in Korea. Soil texture was analyzed using the hydrometer method and the USDA soil texture triangle with air-dried soil (Kroetsch and Wang 2008).

Topographic factors

To determine topographic factors, a 5 m × 5 m Digital Elevation Model (DEM) map from the National Geographic Information Institute (NGII) was analyzed using Quantum Geographic Information System (QGIS) (QGIS Development Team 2023). The elevation, slope, and area of the 30 survey sites were measured using the DEM map and QGIS. The flooding rate was calculated as the proportion of days during three years when the daily water level exceeded the elevation of a given point, based on high-resolution DEM data and daily water gauge records.

Classification of bank types

Bank types were classified into type 1, where water can freely infiltrate from inland areas due to the absence of levees, and type 2, where water inflow is restricted by the presence of artificial levees (Fig. 1; Korea Ministry of Land, Transport and Maritime Affairs 2009). Even within a single site, the left and right banks were sometimes classified as different bank types. A total of 22 banks were classified as type 1, while 38 banks were classified as type 2 (Table S2). Plant cover analysis was conducted by dividing the area from the upper part of the bank to the riverside into three sections. The linear distance from the upper boundary of the levee to the lowest point where vegetation occurred along the riverside was measured, and this continuous distance was subsequently divided into three segments to define standardized upper, middle, and lower sections for analysis (Fig. 1).

Data analysis

Dominant species were identified based on their relative coverage in each bank at each site. Species diversity was quantified using the Shannon–Weaver diversity index. Coverage data were square root-transformed for Huisman-Olff-Fresco (HOF) and redundancy analysis (RDA) analyses. The response of key species was determined using the HOF model (Huisman et al. 1993), which consists of a hierarchical set of predefined models with increasing complexity. The best-fit model was selected by comparing statistical information criteria, which account for both model fit and complexity (Burnham and Anderson 2002). Model types were assigned based on the optimal HOF response selected through AIC-based model comparison, with the best-fitting model type indicated for each species–bank type combination (Gutierrez and Heming 2018).

To compare environmental factors between the two bank types, a one-way ANOVA was conducted for each environmental variable measured in the study. The analysis was performed separately for each of the three transect sections (upper, middle, and lower), and variables with p-values less than 0.05 were considered statistically significant. In addition, Levene's test was conducted to examine the homogeneity of variances between the two groups, confirming that the assumption of equal variances was satisfied ($p > 0.05$). This allowed us to ensure that the significant differences identified by ANOVA were statistically valid.

To explore the relationship between dominant species coverage and environmental variables, RDA was performed using the full integrated dataset. All environmental variables were standardized using z-score normalization to account for differences in measurement scales (Forkman et al. 2019). A RDA was conducted using Monte Carlo permutation tests based on 999 unrestricted random permutations ($p < 0.05$) to identify the environmental variables that significantly influenced species composition (Legendre et al. 2011). All analyses were conducted in R (version 4.2.3) using the "vegan," "tidyverse," and "stats" packages (R Core Team 2023).

Results

Species composition and distribution patterns

Flooding rates varied across the three sections and between bank types. In bank type 1, the average flooding rate was 0.08 ± 0.02% in the upper section, 2.6 ± 5.9% in the middle section, and 18.4 ± 16.5% in the lower section. In bank type 2, the corresponding values were 0.01 ± 0.02%, 3.55 ± 7.79%, and 17.7 ± 18.5% (mean ± standard deviation).

Overall, perennial plants exhibited broader dominance than annual plants. Annual plants were relatively more prevalent in the upper section compared to perennials. The dominant annual plant species were *H. japonicus* and *P. lapathifolia* in both bank types 1 and 2. *H. japonicus* was dominant in the upper and middle sections, with reduced dominance in the lower section, whereas *P. lapathifolia* showed low dominance in the upper section but gradually increased in the middle and lower sections. *Humulus japonicus* was widely distributed in bank areas with a flooding rate of 0% to 40%, but its coverage sharply declined in areas where the flooding rate exceeded 40% (Fig. 2). *Persicaria lapathifolia* was most prevalent in areas with flooding rates between 10% and 20%. *Humulus japonicus* exhibited a sharper decline in coverage at lower flooding rates in bank type 2 wetlands compared to type 1. *Persicaria lapathifolia* showed higher coverage at flooding rates of 10% to 30% across both bank types compared to other species (Table S3).

Among perennial plants, *Miscanthus sacchariflorus* was most dominant in the middle section, with similar levels of dominance in the upper and lower sections. *Phragmites australis* exhibited the highest dominance in the lower section and significant dominance in the middle section. *Artemisia indica* showed high dominance in the upper section, with a decline through the middle and lower sections. At the same time, *Salix pierotii* was most dominant in the

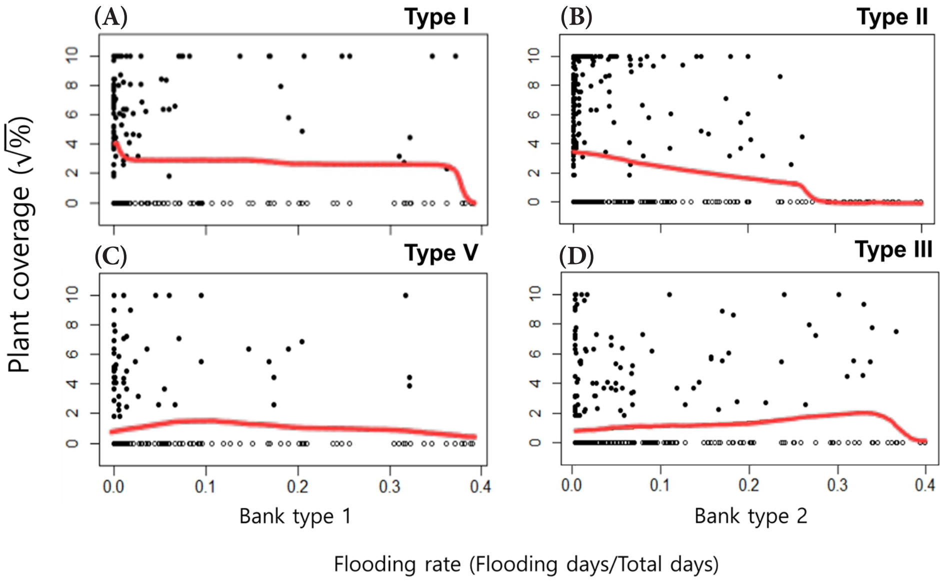

Fig. 2 Huisman-Olff-Fresco (HOF) analysis of flooding rate and annual plant distribution for bank types 1 and 2. (A) and (B) are for *Humulus japonicus*, (C) and (D) are for *Persicaria lapathifolia*. Open circles represent absence, and filled circles represent the presence of plants at each section. The fitted curves follow HOF response Models I, II, III, and V, representing no response, a monotonic trend, a monotonic trend with a plateau, and a skewed unimodal response.

lower section and relatively less dominant in the upper section.

In wetlands with bank type 1, the perennial plant species of *P. australis* and *M. sacchariflorus* were broadly distributed regardless of the flooding rate. *Artemisia indica* and *M. sacchariflorus* showed a sharp decline in coverage when the flooding rate exceeded 10%, whereas *S. pierotii* exhibited an increasing trend in coverage as the flooding rate increased. In bank type 2 wetlands, *P. australis* exhibited a decline in coverage when the flooding rate surpassed 30%. Both *M. sacchariflorus* and *A. indica* showed decreased coverage as the flooding rate increased (Fig. 3, Table S3).

The results of the ANOVA analysis revealed that most environmental factors did not show statistically significant differences ($p > 0.05$) between the two bank types. Specifically, EC, T-N, T-P, clay, and silt showed no significant differences across all sections. Additionally, SOC, pH in the upper and middle sections, and SMC in the middle and lower sections, were also not statistically significant. Three variables exhibited statistically significant differences between bank types in specific sections ($n = 60$). First, SMC in the upper section differed significantly between bank types ($F_{1,58} = 7.45$, $p = 0.008$), with bank type 1 exhibiting higher SMC (0.25 ± 0.08) compared to bank type 2 (0.19 ± 0.09). Second, SOC in the lower section was significantly higher in bank type 1 (0.03 ± 0.01) than in bank type 2 (0.02 ± 0.01) ($F_{1,58} = 4.67$, $p = 0.035$). Lastly, pH in the lower section also showed a significant difference, with bank type 1 averaging 6.89 ± 0.53, compared to 6.55 ± 0.67 in bank type 2 ($F_{1,58} = 5.06$, $p = 0.028$) (Tables S4 and S5).

RDA of plant species coverage in relation to environmental variables

RDA revealed clear multivariate relationships between dominant plant species and environmental gradients across the study sites. The first two RDA axes explained 52.7% and 26.0% of the constrained variation, and permutation tests indicated that the overall model was statistically significant ($F = 5.95$, $p < 0.001$).

Along RDA1, species distributions were structured by sediment and soil chemistry gradients, with silt (100%), T-P (70.8%), SOC (41.8%), and EC (32.0%) loading toward the positive side of the axis, whereas pH (41.8%) and T-N (16.2%) were oriented in the opposite direction (Fig. 4).

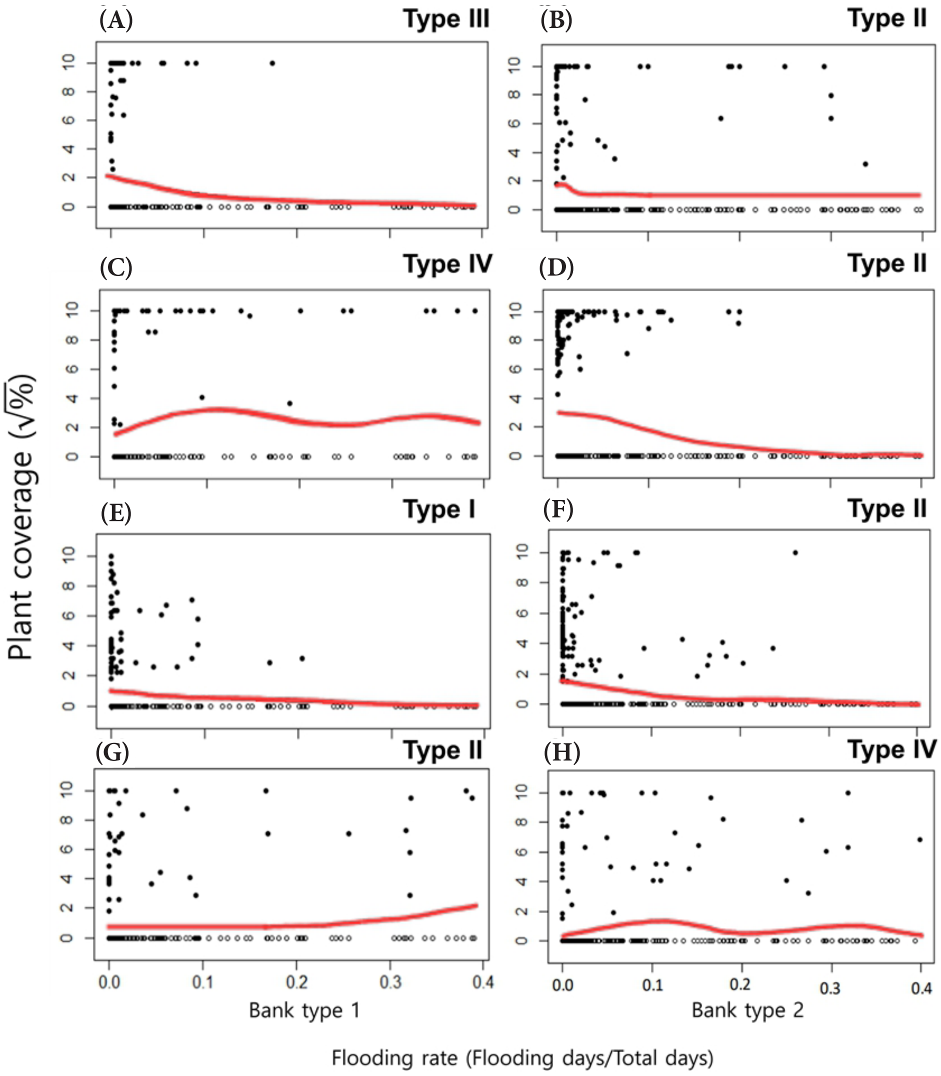

Fig. 3 Huisman-Olff-Fresco (HOF) analysis of flooding rate and perennial plant distribution for bank types 1 and 2. (A) and (B) are for *Miscanthus sacchariflorus*; (C) and (D) are for *Phragmites australis*; (E) and (F) are for *Artemisia indica*; (G) and (H) are for *Salix pierotii*. Open circles represent absence, and filled circles represent the presence of plants within the observed flooding rate range. The fitted curves correspond to HOF response Models I, II, III, and IV, reflecting no response, a monotonic trend, a monotonic trend with a plateau, and a symmetric unimodal response.

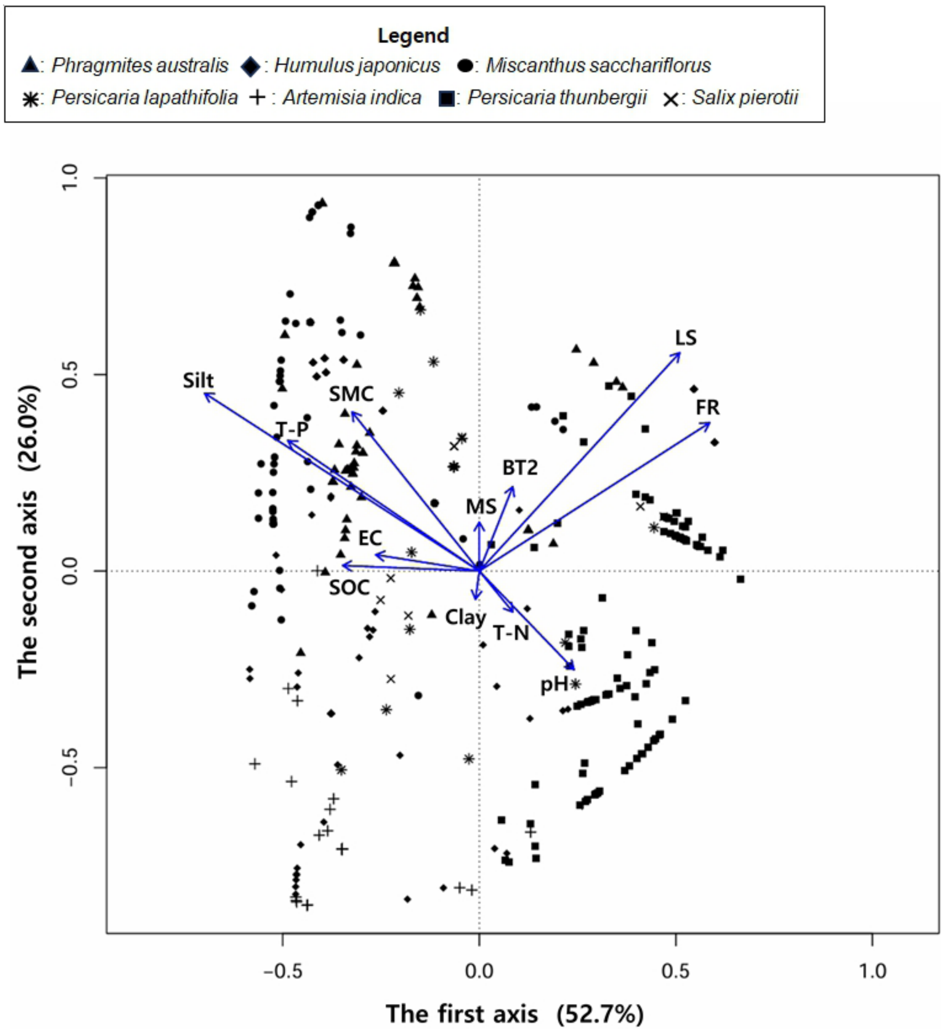

Fig. 4 The results of the redundancy analysis. The percentages on the first and second axes are the interpretations of variations. Environmental variables included soil moisture content (SMC), soil total phosphorus (T-P), soil total nitrogen (T-N), soil electrical conductivity (EC), soil organic carbon (SOC), clay and silt fractions, soil pH, and flooding rate (FR), along with categorical factors representing the middle section (MS), lower section (LS), and bank type 2 (BT2) of the wetland.

Miscanthus sacchariflorus (MS), *H. japonicus* (HJ), and *P. australis* (PA) were positioned toward environments characterized by silt content, soil moisture, and phosphorus availability, indicating strong positive responses to these gradients. *Miscanthus sacchariflorus* also showed a distinct association with pH relative to the other dominant species.

Along RDA2, hydrological and spatial gradients played a dominant role. Variables associated with vertical riverbank position namely the lower section (90.6%), flooding rate (83.7%), SMC (62.3%), and bank type 2 (27.7%) loaded along the vertical axis, indicating substantial influence of inundation frequency and moisture-related edaphic conditions on species distributions across the riparian wetland.

Discussion

Impact of flooding on species diversity

The finding of this study suggest that flooding substantially impacts species diversity within wetland plant communities. Previous studies have demonstrated that flooding leads to a decline in soil oxygen saturation, which in turn limits the establishment of oxygen-sensitive species and favors flood-tolerant taxa (Pezeshki 2001). This phenomenon is evident in the rapid growth and community formation of *M. sacchariflorus*, *Schoenoplectus tabernaemontani*, *P. australis*, and *H. japonicus* (Kim and Kim 2009; Wang et al. 2015; Zhou et al. 2023). These results indicate that species such as *H. japonicus* and *P. australis* are well adapted to the high moisture and low oxygen conditions resulting from flooding (Yamasaki and Tange 1981). Furthermore, the rapid nutrient cycling of *H. japonicus* reflects the survival strategies of species in response to environmental changes induced by flooding, which can lead to shifts in species composition and ecological function within floodplain ecosystems (Guyon and Cosgriff 2022). This adaptation pattern resembles that observed in species such as *P. australis*, emphasizing the role of evolutionary adaptations to flood-related stressors in shaping species diversity (Yamasaki 1990). In contrast to previous research, *M. sacchariflorus* did not exhibit strong tolerance at higher flooding rates and instead tended to decline. This trend may be due to the plant's frequent occurrence at higher elevations, such as the upper section of banks, where it is less exposed to prolonged flooding (Cho and Cho 2005; Park and Kim 2020).

Soil characteristics of plant composition

Key variables identified through RDA, including SMC, pH, SOC, and silt, play significant roles in plant growth and distribution (Hood 2001; Neina 2019; Zhao et al. 2011). The fact that different primary variables influenced plant distribution in each bank type highlights how plant communities may shift based on bank type and environmental conditions.

Plants such as *M. sacchariflorus* responded sensitively to soil pH and moisture levels, which affected their distribution and growth patterns (Jiao et al. 2020; Sarkar et al. 2015). This finding illustrates the impact of soil physicochemical properties on the growth and adaptation of individual plant species.

Soil moisture and organic content are closely related to plants' physiological stress responses, which can explain the dominance of certain species or a reduction in diversity within floodplain ecosystems (Eskelinen et al. 2009). *Humulus japonicus* showed high dominance under conditions of high soil moisture and low oxygen, serving as a key example of how soil characteristics influence plant competitiveness and community composition (Guyon and Cosgriff 2022). Thus, the physical and chemical properties of soil serve as primary factors determining the ecological roles of plants and their positions within communities in specific habitats.

Differences in soil moisture distribution by bank type

Differences in SMC between bank types have a direct impact on plant growth and distribution. In this study, bank type 1 lacked a levee, allowing water from the inland area to flow more freely into the river ecosystem. This resulted in a wider and more varied distribution of SMC. The increased and broader distribution of soil moisture promotes soil organic matter decomposition, reduces the availability of T-P, and alters pH levels (Maranguit et al. 2017; Qu et al. 2021; Ragot et al. 2016). These conditions create an environment that supports moisture-tolerant and adaptable plant species, such as *P. australis* and *M. sacchariflorus*, which are better suited to bank type 1 compared to bank type 2, allowing them to form broader communities (Fried et al. 2018; Park and Kim 2020). This finding aligns with previous research suggesting that *H. japonicus* can grow vigorously over species like *P. australis*, benefiting from these conditions (Kim and Kim 2009).

In contrast, SMC in bank type 2 was more concentrated, displaying a different pattern from that of bank type 1. In bank type 2 wetlands, *H. japonicus* coverage sharply declined when the flooding rate exceeded 30%. This trend appears to result from its aboveground parts being vulnerable to rapid water flow (Lee et al. 2006). Additionally, unlike in bank type 1, where *H. japonicus* maintained a more consistent distribution, the less uniform soil moisture in type 2 may prevent it from overtaking species like *P. australis* or *M. sacchariflorus*, leading to reduced coverage (Kim and Kim 2009). This variation in the distribution patterns of *P. australis* and *H. japonicus* appears to contribute to the differences in species diversity indices observed between the two bank types (Bonello and Judd 2020; Gratton and Denno 2005).

These differences in SMC also influenced the flooding rate for each bank type. The lower impact of flooding observed in bank type 1 compared to bank type 2 can be interpreted as a consequence of soil moisture flowing down from the upper areas of the bank.

Conclusions

This study analyzed the effects of flooding rate and bank type on plant species composition and soil characteristics in riparian wetlands. The findings indicate that both flooding rate and bank type significantly impact the growth and distribution of certain plant species. In frequently flooded areas, flood-tolerant species such as *P. australis* were dominant, which can be attributed to their adaptation to high moisture and low oxygen conditions resulting from flooding.

The analysis by bank type revealed that bank type 1, which lacks a levee, allows water to flow into the area, resulting in a broader zone with higher SMC. This favors the distribution of moisture-tolerant species like *P.* australis and *H. japonicus*. In contrast, bank type 2 restricts water flow, causing moisture to concentrate in specific areas, which contributes to a reduction in plant species diversity. RDA revealed that key environmental factors shaping plant species composition included sediment and soil chemistry variables such as silt, T-P, SOC, EC, pH, and T-N, as well as hydrological and spatial gradients including flooding rate, soil moisture, lower-section in riparian wetland, and bank type. In conclusion, the interaction between flooding rate and bank type plays an essential role in maintaining ecological balance in riparian wetlands. These findings provide valuable insights for the effective design of levees and the development of wetland management strategies. Based on this study, it is essential to explore sustainable wetland management approaches and implement strategies to enhance biodiversity in these ecosystems.

Supplementary Information

Supplementary information accompanies this paper at https://doi.org/10.5141/jee.25.088.

Fig. S1. Location of study sites in the Han River. Black circles indicate the riparian wetlands as study sites. **Table S1.** Survey locations. **Table S2.** Classification of wetland banks by type. **Table S3.** HOF-derived species response properties across bank types 1 and 2. **Table S4.** Soil characteristics and flooding rate at the two banksides (mean ± 1ST). **Table S5.** ANOVA results comparing environmental variables between Bank type 1 and Bank type 2 across three sections.

Abbreviations

DEM: Digital Elevation Model
EC: Electrical conductivity
HOF: Huisman-Olff-Fresco
NGII: National Geographic Information Institute
RDA: Redundancy Analysis
QGIS: Quantum Geographic Information System
SMC: Soil moisture content
SOC: Soil organic matter content
T-N: Total nitrogen
T-P: Total phosphorus

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Authors' contributions

Kun Woo Kim: Writing – original draft, Writing – review and editing, Data curation, Formal analysis, Investigation, Methodology, Validation, Visualization, Conceptualization. Jae Geun Kim: Writing – review and editing, Conceptualization, Funding acquisition, Methodology, Resources, Supervision.

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Availability of data and materials

The datasets used and/or analyzed in the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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