Distribution patterns of plant communities and their associations with environmental soil factors on the eastern shore of Lake Taihu, China

Wei Li, Lijuan Cui, Baodi Sun, Xinsheng Zhao, Changjun Gao, Yan Zhang, Manyin Zhang, Xu Pan, Yinru Lei, and Wu Ma

*Institute of Wetland Research, Chinese Academy of Forestry, Beijing, China; †Beijing Key Laboratory of Wetland Services and Restoration, Beijing, China; ‡School of Natural Resources, West Virginia University, Morgantown, USA

**ABSTRACT**

**Introduction:** Plant communities and soil factors might interact with each other in different temporal and spatial scales, which can influence the patterns and processes of the wetland ecosystem. To get a better understanding of the distribution of plants in wetlands and analyze their associations with environmental soil factors, the structure and types of plant communities in the eastern shore area of Lake Taihu were analyzed by two-way indicator species analysis and canonical correspondence analysis (CCA) ordination. The spatial distribution patterns of vegetation and the main factors affecting the distributions were investigated.

**Outcomes:** Sixty-six sampling sites were selected to obtain vegetation species and soil environmental factor data. Results showed that 22 species from the 66 sites could be divided into seven communities: I: Arundo donax; II: A. donax + Phragmites australis; III: Zizania latifolia + Typha orientalis; IV: P. australis + Alternanthera philoxeroides + Polygonum hydropiper; V: P. australis; VI: P. australis + Humulus scandens; and VII: Erigeron acer + Ipomoea batatas + Rumex acetosa. Plant species and soil factors in the CCA analysis showed that I. batatas, E. acer, Chenopodium album, Polygonum lapathifolium, and Acalypha australis were mainly affected by pH, whereas Echinocloa crus-galli, Setaria viridis, and H. scandens were mainly affected by soil total phosphorus. Mentha canadensis and A. donax were mainly affected by soil conductivity, A. philoxeroides was mainly affected by soil organic matter and, Z. latifolia, Metaplexis japonica and P. hydropiper were mainly affected by available phosphorus.

**Conclusion:** These results indicated that different plants adapted to different soil environmental factors and provided basic information on the diversity of Lake Taihu wetland vegetation.

**Introduction:** Wetlands are important habitats for many species of plants and animals at both national and international levels (Skeffington et al. 2006; Hebb et al. 2013; Wetser et al. 2015). A contribution to our understanding of how a community is put together, how it works, what determines the relative proportions of community members, and their spatial and temporal relationships with each other might contain something of value for describing wetlands. The vegetation in wetlands has been described by a number of authors who distinguished a variable number of wetland plant communities (Casanova and Brock 2000; Dekeyser, Kirby, and Ell 2003; O’Connell et al. 2012; Williams and Ahn 2015); these works suggested various aspects of soil conditions to be the main environmental factors affecting wetland plant communities, namely soil water content and soil nutrients including nitrogen, phosphorus, and organic carbon (Gilliam 2006; Li et al. 2010; Zheng, Chen, and Wu 2013; Jager et al. 2015; Wang et al. 2016). Wetland vegetation can effectively absorb nutrients from the surrounding soil. As early as 1947, Watt wanted to know how the vegetation structure affected the microclimate and soil conditions; he found that the plants in his study areas were obviously patchy and the patches were irregular in size and shape and their juxtaposition varied. Benning and Seastedt (1995) emphasized how vegetation patterns affected the soil moisture, nutrients, and other processes detailed. The relationship between vegetation and soil environmental factors has been widely discussed (Juan, Carlos, and Donald 2011; Mellado and Zamora 2015; Liu et al. 2016; Lucie, Jana, and Zuzana 2016). Soil environmental factors have important effects on plant growth and reproduction. Kang, Kang, and Ko (2002) found that wetland ecosystems dominated by Phragmites japonica absorbed more than 66% of the inorganic nitrogen from the soil, concluding that the study area had strong absorption ability for soil nitrogen. The demand for nutrients in wetland plants also changes with the seasons (Picard, Fraser, and Steer 2005). Previous studies also showed that wetland vegetation was the main factor influencing nutrient retention,
Vegetation data were collected at each site in August 2010. Sixty-six sites were established (Figure 1), with three small plots (1 m × 1 m) at each site. All vascular plant species were surveyed, and species identification was carried out. The information recorded at each
site included plant species, height, abundance, density, plant frequency, total coverage, and coverage of each species. The 66 sites were set up to systematically measure the characteristic parameters of the plants. At each site, the geographic location (LAT and LONG) was recorded with a handheld GPS unit (Garmin GPS62sc, Taiwan, China). The main plant species in the different sampling plots are presented in Table 1.

Soil types are mainly yellow and black soils in the study area. In each vegetation sample plot, three sample plots (10 cm × 10 cm) were randomly established to demonstrate the representativeness of each plot. Soil samples (0–20 cm) were collected and placed in new clean polythene bags. Soil samples were air-dried and the three soil samples from each sampling plot were evenly mixed and taken to the laboratory for analysis. Soil moisture content (MC), pH, conductivity (Cond), soil organic matter (SOM), total nitrogen, total phosphorus, potassium (K⁺), ammonium-nitrogen (NH₄-N), available phosphorus (A-P), available nitrogen (A-N), and nitrate-N were analyzed, which together formed a 66 × 11 matrix of environmental factors. The soil analytical methods used for MC and environmental chemical factors were those described by Pansu and Gautheyrou (2006).

Table 1. Main plant species in the study area.

| Plant species                  | No.          | Sampling plots of species |
|-------------------------------|--------------|--------------------------|
| Echinochloa crus-galli        | P1           | 1,2,15,16,26,31,39,42,50,57,58,59,60,61 |
| Mentha canadensis             | P2           | 19,44,45,46,47,48        |
| Ipomoea batatas               | P3           | 53,54,55                 |
| Erigeron acer                 | P4           | 13,17,21,23,24,37,38,39,40,41,51,57,61,64 |
| Setaria viridis               | P5           | 19,21,23,26,28,31,38,39,57,59,61,63 |
| Bidens pilosa                 | P6           | 1,16,34,42,51,59        |
| Chenopodium album             | P7           | 36,37,38,54,58,60       |
| Leersia japonica              | P8           | 14,15,16,40,47,52,56 |
| Z. latifolia                  | P9           | 4,12,19,21,22,24,25,27,31,32,35,50,65 |
| Epilobium hirsutum            | P10          | 11,34,43,44,45,58,59,61 |
| P. australis                  | P11          | 1,2,4,5,7,8,9,10,11,12,13,15,16,20,21,24,26,27,28,29,30,31,34,35,37,42,43,44,45,46,47,49,50,51,52,53,54,56,57,58,59,61,62,63,64,65,66 |
| A. donax                      | P12          | 2,3,5,6,10,17,18,19,22,24,29,41,43,44,45,46,48 |
| Humulus scandens              | P13          | 1,4,12,14,18,19,24,26,29,37,42,48,51,55,57,58,59,60,61,62,64,65,66 |
| Metaplexis japonica           | P14          | 6,20,21,30,46,61,63,64,65 |
| Polygonum hydropiper          | P15          | 1,2,4,7,8,12,13,14,17,18,27,28,30,31,33,36,47,49,51,52,57,58,60,61,62,63,66 |
| Rumex acetosa                 | P16          | 37,38,39,40,41          |
| Polygonum lapathifolium       | P17          | 37,38,40,42,46,49       |
| Sesbania cannabina            | P18          | 11,20,25,31,33,34,39,41,59,61 |
| Acalypha australis            | P19          | 23,40,45,48,53,54,58,59,60 |
| A. philoxeroides              | P20          | 4,6,12,13,14,15,16,17,18,19,20,22,24,25,27,28,30,33,34,35,36,37,40,41,42,43,47,48,50,51,52,56,61,63,64,65,66 |
| T. orientalis                 | P21          | 4,28,29,36,41,42,45,52 |
| Glycine max                   | P22          | 11,22,29,37,42,46,56,57,58,59,60,61 |
Data analyses

The following equation (Qiu and Zhang 2000) was used to calculate species importance value of an herb:

\[
\text{Species importance value of an herb} = \frac{\text{relative height} + \text{relative cover} + \text{relative density}}{3}
\]  

(T1)

TWINSPAN is internationally accepted as a hierarchical classification method that can simultaneously complete plot and species classifications and is widely used in vegetation ecology (Niall et al. 2007; Nkosi, Barrett, and Brown 2016). Ordination techniques reveal correlations between the spatial distribution of plant communities and environmental factors, which might have extremely important ecological significance (Kajsa and Johanna 2005). Ordination methods applied to plant communities can be divided into two types: direct and indirect (Zdravko 2005). Ordination theory has become an indispensable method in modern ecological vegetation studies because it objectively reflects the relationships between the spatial distribution of vegetation and environmental factors (Juan, Carlos, and Donaldo 2011). Canoco for Windows v4.5 was used in the CCA analysis to investigate the relationships between vegetation distribution and environmental factors. The nature of the relationships is shown in the ordination diagram by vectors with lengths proportional to their importance and directions showing their correlations with each axis. Soil variables were centered, standardized, and submitted to the Canoco “forward selection of explanatory variables” to avoid any artificial increase in the explained variation (Peres-Neto et al. 2006). A Monte Carlo permutation test was performed to determine the accuracy of the relationship (999 randomizations) between the two data sets.

Results

TWINSPAN classification

The abundance matrix of 22 plant species at the 66 sampling sites was used to analyze the vegetation communities by TWINSPAN. The study area average MC was 29% and average elevation about 4 m in the Eastern Taihu lakeshore, China. The phytosociological table is shown in the Appendix. The plant communities in the study area were divided into seven types (Figure 2), with each being named based on the dominant species at each level and the indicator species classified by TWINSPAN.

(1) Community I: A. donax

Community I included sampling sites 6, 19, 22, 48, and 46. Other associated species included A. australis, A. philoxeroides, E. hirsutum, G. max, H. scandens, M. canadensis, M. japonica, P. australis, S. viridis, and Z. latifolia.

(2) Community II: A. donax + P. australis

Community II included sampling sites 3, 5, 10, 44, and 45. Other associated species included P. hydro Piper, M. canadensis, E. hirsutum, and T. orientalis.

(3) Community III: Z. latifolia + T. orientalis

![Figure 2. TWINSPAN classification of the 22 plant species.](image-url)
Community III included sampling sites 25, 32, 28, 36, and 52. Other associated species included A. philoxeroides, C. album, L. japonica, P. australis, P. hydropiper, S. cannabina, and S. viridis.

(4) Community IV: P. australis + A. philoxeroides + P. hydropiper

Community IV included sampling sites 2, 17, 18, 33, 1, 7, 14, 15, 47, 49, 51, 4, 8, 9, 12, 24, 27, 35, 62, 65, 66, and 13. Other associated species included A. donax, Bidens pilosa, E. crus-galli, E. acer, H. scandens, L. japonica, M. canadensis, M. japonica, P. lapathifolium, S. cannabina, S. viridis, T. orientalis, and Z. latifolia.

(5) Community V: P. australis

Community V included sampling sites 21, 64, 20, 30, 63 and 31, and 50, 11, 34, 16, 42 and 56. Other associated species included A. philoxeroides, E. crus-galli, E. hirsutum, E. acer, G. max, H. scandens, M. japonica, P. hydropiper, S. cannabina, S. viridis, and Z. latifolia.

(6) Community VI: P. australis + H. scandens

Community VI included sampling sites 58, 59, 60, 26, 57, 61, and 29. Other associated species included A. australis, A. philoxeroides, A. donax, B. pilosa, C. album, E. crus-galli, E. hirsutum, E. acer, G. max, M. japonica, P. hydropiper, S. cannabina, S. viridis, and T. orientalis.

(7) Community VII: E. acer + I. batatas + R. acetosa

Community VII included sampling sites 53, 54, 55, 23, 37, 38, 40, 39, and 41. Other associated species included A. australis, A. philoxeroides, A. donax, C. album, E. crus-galli, H. scandens, L. japonica, P. australis, P. lapathifolium, S. cannabina, S. viridis, and T. orientalis.

When the seven plant communities were analyzed, we found that A. donax distributed in both Communities I and II including 11 sites. P. australis distributed in Communities IV, V, and VI including 41 sites. These two plants were present in more communities and more sites than the other plants. Communities I and V were dominated by one plant: A. donax and P. australis, respectively. Communities II, III, and VI were dominated by two main plant types, and Communities IV and VII were dominated by three main plant types.

Relationship between vegetation spatial distribution and environmental factors

CCA was used to analyze the relationship between the 11 soil factors and wetland vegetation distribution on the Taihu lakeshore. Figure 3 is based on the species importance value and presents the results of CCA ordination of the species–environment relationships in the region (Table A1). The distribution of I. batatas, E. acer, C. album, P. lapathifolium, and A. australis was mainly affected by soil pH. The distribution of E. crus-galli, S. viridis, and H. scandens was mainly affected by soil TP (total phosphorus). The distribution of M. canadensis and A. donax was mainly affected by soil Cond. The distribution of A. philoxeroides was mainly affected by SOM. The distribution of Z. latifolia, M. japonica, and P. hydropiper was mainly affected by A-P.

The eigenvalues of the first two ordination axes are 0.358 and 0.258, respectively, and the correlation coefficients for the first three vegetation species axes and environmental factor axes are 0.793, 0.747, and 0.680, respectively (Table 2). CCA ordination of the first three vegetation axes retained only 16.6% of the total variance of data, so the analysis might be missing a large part of the species information.

Discussion

Relationship between vegetation and soil factors

The relationship between vegetation and environmental soil factors was assessed with CCA ordinations. The results of the ordination analysis showed that the cumulative percentage for the correlations between species and environmental factors for the first two axes explained 57.6% of the total variance. This indicated that soil environmental factors had a large impact on the distribution pattern of wetland
Table 2. Eigenvalues, species–environment correlation coefficients, and cumulative percentage for the first four axes.

| Axes | 1     | 2     | 3     | 4     |
|------|-------|-------|-------|-------|
| Eigenvalues | 0.358 | 0.258 | 0.159 | 0.096 |
| Correlation coefficients for species axes and environmental factor axes | 0.793 | 0.747 | 0.680 | 0.537 |
| Vegetation data cumulative percentage | 7.7   | 13.2  | 16.6  | 18.7  |
| Cumulative percentage for the correlations of species and environmental factors | 33.5  | 57.6  | 72.5  | 81.5  |

plant communities. It has been suggested that the results of this type of analysis can be useful if the variance of eigenvectors represents over 40% of the total variance. Consequently, the first two axes are sufficient to reflect the relationship of vegetation species and environmental factors.

Vegetation and soil are the most conspicuous resources of wetlands. Quantifying the variation in species diversity and community composition with location provided the opportunity to infer possible mechanisms of vegetation community assembly (Kadowaki et al. 2014; Reid, Reid, and Thoms 2016; Yamaji et al. 2016). Similar results were found in lowlands, temperate forests, arid grasslands, beech forests, and natural forest (Peres-Neto et al. 2006; Dwirek, Kauffman, and Baham 2006). We found that the main factors affecting vegetation distribution were SOM, Cond, pH, TP, and A-P. SOM provides nutrients to plants, ensures plant production and development, and plays an important role in the sustainable development of the wetland. Cond contains rich information about physical properties and soil quality, which is crucial for plant growth (Jager et al. 2015). Soil pH was an important determinant of the productivity of a site and in the separation of plant groups (Dong et al. 2014). The effects of soil pH were both direct and indirect; direct effects were evidenced by the plant shape, material metabolism, growth, quality, and yield, while indirect effects were reflected in the impact of soil physical, chemical, and biological characteristics on plant growth (Kashian et al. 2003; Rola, Oszczka, and Nobis 2015). Phosphorus plays a fundamental role in plant nutrition and the concentration and availability of P determines to great extent the soil fertility and site productivity as P is required in relatively large amounts by plants. Bigelow and Canham (2002) observed a direct correlation between P and the distribution of plant species in northeastern America. Amorim and Batalha (2007) reported that P was the main factor that defined plant communities in Brazil, and nutrients in general played a major role in the classification of plant groups. A-P in the soil can be absorbed by the plant component; many other studies have noted the role of A-P in the distribution pattern of plant communities (Hammersmark et al. 2009; Mellado and Zamora 2015; Onur and Suha 2016).

The study of vegetation distribution in the eastern shore of Lake Taihu is important, as it is one of the key watershed wetlands in China. In addition to soil factors, the distribution of plant communities might be related to the specific geographical location providing unique habitats (Wassen, Peeters, and Venterink 2002; Dwirek, Kauffman, and Baham 2006; Mellado and Zamora 2015; Oliveira, Torezan, and Cunha 2015; Zellweger et al. 2015; Whitworth et al. 2016). The plant communities in the study area were divided into seven types, which had substantial differences in their growth requirements. The ordination analysis showed the correlation between wetland vegetation composition, species distribution, and the soil environment.

One of the main factors responsible for the separation of Communities I and II was soil conductivity. This was consistent with the finding that soil conductivity was one of the most important factors in structuring plant communities (Peres-Neto et al. 2006; Corriale, Picca, and Francescantonio 2013) and that A. donax, growing in Community I, tended to occur on clay soils. Only certain species, such as Z. latifolia and T. orientalis, were able to grow in Community III, and A-P was important in structuring this community; A-P was usually an important factor for vegetation development and distribution in wetlands and therefore it was significant in vegetation restoration in such areas (Ladányi et al. 2016). SOM might be rich in Community IV, and it characteristically had a high adsorption capability, which increased the exchange capacity of the soil and therefore improves its fertility levels (Zhang, Yu, and Hu 2013). Total phosphorus was important in structuring Community VI, while pH was the most important factor in structuring Community VII.

Guiding significance for wetland restoration

In soil–vegetation systems, soil and vegetation are interdependent on each other. Soil influences vegetation and vegetation restricts soil (Sarah, Zhevelev, and Atar 2015; Zielke et al. 2015). The results not only showed that the soil factors played an important role in the vegetation community succession process, but also revealed that the vegetation community played an important role in soil restoration and reconstruction.

Besides the factors examined in this paper, there are many other factors with the potential to affect the plant communities in wetlands. For example, soil microbes are considered to be a key determinant of the aboveground plant community (Zuo et al. 2016). They do not
Arch effects will influence the accuracy observed in this study. Arch effects can help improve the management, reclamations, and development of wetland ecosystems.

In the process of succession, the spatial distribution and aggregation of vegetation communities corresponded to the vegetation community dynamic state and spatial heterogeneity (Sui et al. 2010; Boy et al. 2016). So, understanding the current vegetation and the distribution patterns of plant communities can promote the succession of vegetation restoration. Vegetation acted as one of the most important factors in wetland ecosystems, and distribution patterns of plant communities strongly affected wetland ecosystem properties (Zelnik, Haler, and Gaberščik 2015; Hwang et al. 2016; Zuo et al. 2016). According to Zuo et al. (2016), the recovery of vegetation succession can provide theoretical support for wetland restoration and health evaluation. Vegetation classification is the key step to choosing suitable plant species and formulating reasonable vegetation restoration measures. By understanding the differences between and the characteristics of different soil conditions in Lake Taihu, we can choose the most appropriate plant species for vegetation restoration and highlight the crucial role of local variation in soil properties for regulating plant trait selection and species composition.

The CCA model is nonlinear, which has several advantages that have been confirmed in several previous studies (Sui et al. 2010; Zhang, Yu, and Hu 2013; Sarah, Zhevelev, and Atar 2015). The limitation of CCA is that the direction of the second axis can vary from that of the first axis in many cases, known as the “arch effect” or “horsehoe effect.” Arch effects will influence the accuracy of sorting, especially for the environmental variables in this study; this is one reason why CCA only explains 16.6% of variation with the first three axes in this paper. Future studies could use detrended canonical correspondence to overcome the “Arch effects” observed in this study. Although we used CCA to analyze the relationship between the vegetation distribution and soil environmental factors in this paper, the complexity of the natural environment and the long-term nature of vegetation restoration succession make wetland vegetation restoration research very difficult. In the future, we should base our studies on wetland soil properties in areas of restored wetland vegetation, consider using artificial methods to promote vegetation restoration, and combine artificial and natural vegetation recovery methods to facilitate wetland restoration.

In this paper, we mainly analyzed the interaction between the distribution pattern of plant communities and environmental soil factors; the results also presented some relatively remarkable effects. However, we did not analyze other environmental factors including atmosphere, water level, climate, rainfall, or others, which resulted in some uncertainty in this paper. To achieve better theoretical support, future studies should aim to include more environmental factors with multiple analyses.

Acknowledgments

The research in this article was funded by the Special Forestry Project of Public Interests (201404305 and 200904001). We thank Amjad Ali and Abel Ramoelo for valuable comments on the draft of the paper and John Wasige from the University of Twente, The Netherlands, for his linguistic help. We also thank Edanz Editing China for linguistic assistance.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

The research in this article was funded by the Special Forestry Project of Public Interests [201404305, 200904001].

ORCID

Lijuan Cui http://orcid.org/0000-0002-2133-9287

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Casanova, M. T., and M. A. Brock. 2000. “How Do Depth, Duration and Frequency of Flooding Influence the
| Sampling sites | E. chloa | M. canadensis | I. batatas | E. acer | S. viridis | B. pilosa | C. album | L. japonica | Z. latifolia | E. hirsutum | P. australis | A. donax | H. scandens | M. japonica | P. hydropiper | R. acetosa | P. lapathifolium | S. cannabina | A. australis | A. philoxeroides | T. orientalis | G. max |
|---------------|---------|--------------|-----------|--------|----------|--------|-------|-----------|-----------|-----------|----------|-------|--------|-----------|-----------|--------|--------------|---------|-----------|-----------|-----------|-------|
| P1            | 10.32   | 25.85        | 6.33      | 0      | 0        | 4.43   | 0     | 0.53      | 10.98     | 16.81     | 0        | 16.81  | 14.84   | 9.71     | 8.59   | 11.92       | 0.14    | 0.14      | 0.14      | 0.14      | 0.14  |
| P2            | 8.17    | 0            | 0        | 0      | 0        | 10.32  | 0     | 0         | 1.12      | 1.12      | 0        | 1.12   | 0.67    | 0.67     | 0      | 0            | 0       | 0        | 0        | 0        | 0    |
| P3            | 0       | 0            | 0        | 0      | 0        | 0      | 0     | 0         | 0         | 0         | 0        | 0     | 0       | 0        | 0        | 0      | 0            | 0       | 0        | 0        | 0        | 0    |
| P4            | 0       | 0            | 0        | 0      | 0        | 0      | 0     | 0         | 0         | 0         | 0        | 0     | 0       | 0        | 0        | 0      | 0            | 0       | 0        | 0        | 0        | 0    |
| P5            | 0       | 0            | 0        | 0      | 0        | 0      | 0     | 0         | 0         | 0         | 0        | 0     | 0       | 0        | 0        | 0      | 0            | 0       | 0        | 0        | 0        | 0    |
| P6            | 0       | 0            | 0        | 0      | 0        | 0      | 0     | 0         | 0         | 0         | 0        | 0     | 0       | 0        | 0        | 0      | 0            | 0       | 0        | 0        | 0        | 0    |
| P7            | 0       | 0            | 0        | 0      | 0        | 0      | 0     | 0         | 0         | 0         | 0        | 0     | 0       | 0        | 0        | 0      | 0            | 0       | 0        | 0        | 0        | 0    |
| P8            | 0       | 0            | 0        | 0      | 0        | 0      | 0     | 0         | 0         | 0         | 0        | 0     | 0       | 0        | 0        | 0      | 0            | 0       | 0        | 0        | 0        | 0    |
| P9            | 0       | 0            | 0        | 0      | 0        | 0      | 0     | 0         | 0         | 0         | 0        | 0     | 0       | 0        | 0        | 0      | 0            | 0       | 0        | 0        | 0        | 0    |
| P10           | 0       | 0            | 0        | 0      | 0        | 0      | 0     | 0         | 0         | 0         | 0        | 0     | 0       | 0        | 0        | 0      | 0            | 0       | 0        | 0        | 0        | 0    |
| P11           | 0       | 0            | 0        | 0      | 0        | 0      | 0     | 0         | 0         | 0         | 0        | 0     | 0       | 0        | 0        | 0      | 0            | 0       | 0        | 0        | 0        | 0    |
| P12           | 0       | 0            | 0        | 0      | 0        | 0      | 0     | 0         | 0         | 0         | 0        | 0     | 0       | 0        | 0        | 0      | 0            | 0       | 0        | 0        | 0        | 0    |
| P13           | 0       | 0            | 0        | 0      | 0        | 0      | 0     | 0         | 0         | 0         | 0        | 0     | 0       | 0        | 0        | 0      | 0            | 0       | 0        | 0        | 0        | 0    |
| P14           | 0       | 0            | 0        | 0      | 0        | 0      | 0     | 0         | 0         | 0         | 0        | 0     | 0       | 0        | 0        | 0      | 0            | 0       | 0        | 0        | 0        | 0    |
| P15           | 0       | 0            | 0        | 0      | 0        | 0      | 0     | 0         | 0         | 0         | 0        | 0     | 0       | 0        | 0        | 0      | 0            | 0       | 0        | 0        | 0        | 0    |
| P16           | 0       | 0            | 0        | 0      | 0        | 0      | 0     | 0         | 0         | 0         | 0        | 0     | 0       | 0        | 0        | 0      | 0            | 0       | 0        | 0        | 0        | 0    |
| P17           | 0       | 0            | 0        | 0      | 0        | 0      | 0     | 0         | 0         | 0         | 0        | 0     | 0       | 0        | 0        | 0      | 0            | 0       | 0        | 0        | 0        | 0    |
| P18           | 0       | 0            | 0        | 0      | 0        | 0      | 0     | 0         | 0         | 0         | 0        | 0     | 0       | 0        | 0        | 0      | 0            | 0       | 0        | 0        | 0        | 0    |
| P19           | 0       | 0            | 0        | 0      | 0        | 0      | 0     | 0         | 0         | 0         | 0        | 0     | 0       | 0        | 0        | 0      | 0            | 0       | 0        | 0        | 0        | 0    |
| P20           | 0       | 0            | 0        | 0      | 0        | 0      | 0     | 0         | 0         | 0         | 0        | 0     | 0       | 0        | 0        | 0      | 0            | 0       | 0        | 0        | 0        | 0    |
| P21           | 0       | 0            | 0        | 0      | 0        | 0      | 0     | 0         | 0         | 0         | 0        | 0     | 0       | 0        | 0        | 0      | 0            | 0       | 0        | 0        | 0        | 0    |
| P22           | 0       | 0            | 0        | 0      | 0        | 0      | 0     | 0         | 0         | 0         | 0        | 0     | 0       | 0        | 0        | 0      | 0            | 0       | 0        | 0        | 0        | 0    |

Table A1: Species importance value of each herb.

See Table A1.
Table A1. (Continued).

| Sampling sites | E. chloa crus-galli | M. canadensis | I. batatas | E. acer | S. viridis | B. pilosa | C. album | L. japonica | Z. latifolia | E. hirsutum | A. donax | H. scandens | M. japonica | P. hydroplium | A. acutosa | P. philoxeraoides | T. orientalis | G. max |
|----------------|---------------------|---------------|------------|--------|-----------|----------|---------|-------------|-------------|-------------|---------|-----------|-------------|--------------|----------|-----------------|--------------|-------|
|                | P1 P2 P3 P4 P5 P6 P7 P8 P9 P10 P11 P12 P13 P14 P15 P16 P17 P18 P19 P20 P21 P22 |                |            |        |           |          |         |              |              |             |          |           |             |              |          |                 |              |       |
| 40             | 0 0 0 31.20 0 0 0 7.29 0 0 0 0 0 0 0 0 29.83 4.12 0 0 0 0 |                |            |        |           |          |         |              |              |             |          |           |             |              |          |                 |              |       |
| 41             | 0 0 0 37.06 0 0 0 0 0 0 0 0 7.15 0 0 0 0 0 0 0 0 0 0 0 0 |                |            |        |           |          |         |              |              |             |          |           |             |              |          |                 |              |       |
| 42             | 3.50 0 0 0 0 4.17 0 0 0 0 0 0 0 0 48.61 0 7.06 0 0 0 0 0 0 |                |            |        |           |          |         |              |              |             |          |           |             |              |          |                 |              |       |
| 43             | 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 |                |            |        |           |          |         |              |              |             |          |           |             |              |          |                 |              |       |
| 44             | 0 10.83 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 |                |            |        |           |          |         |              |              |             |          |           |             |              |          |                 |              |       |
| 45             | 0 5.08 0 0 0 0 0 0 0 0 0 0 0 37.13 17.87 28.80 0 0 0 0 0 0 413 0 6.99 |                |            |        |           |          |         |              |              |             |          |           |             |              |          |                 |              |       |
| 46             | 0 7.51 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 |                |            |        |           |          |         |              |              |             |          |           |             |              |          |                 |              |       |
| 47             | 0 8.80 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 |                |            |        |           |          |         |              |              |             |          |           |             |              |          |                 |              |       |
| 48             | 0 31.54 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 |                |            |        |           |          |         |              |              |             |          |           |             |              |          |                 |              |       |
| 49             | 0 0.00 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 |                |            |        |           |          |         |              |              |             |          |           |             |              |          |                 |              |       |
| 50             | 4.29 0.00 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 |                |            |        |           |          |         |              |              |             |          |           |             |              |          |                 |              |       |
| 51             | 0 0.00 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 |                |            |        |           |          |         |              |              |             |          |           |             |              |          |                 |              |       |
| 52             | 0 0.00 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 |                |            |        |           |          |         |              |              |             |          |           |             |              |          |                 |              |       |
| 53             | 0 0.00 54.35 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 |                |            |        |           |          |         |              |              |             |          |           |             |              |          |                 |              |       |
| 54             | 0 0.00 51.94 0 0 0 8.63 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 |                |            |        |           |          |         |              |              |             |          |           |             |              |          |                 |              |       |
| 55             | 0 0.00 42.63 0 0 18.18 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 |                |            |        |           |          |         |              |              |             |          |           |             |              |          |                 |              |       |
| 56             | 0 0.00 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 |                |            |        |           |          |         |              |              |             |          |           |             |              |          |                 |              |       |
| 57             | 8.91 0.00 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 |                |            |        |           |          |         |              |              |             |          |           |             |              |          |                 |              |       |
| 58             | 11.82 0.00 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 |                |            |        |           |          |         |              |              |             |          |           |             |              |          |                 |              |       |
| 59             | 20.81 0.00 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 |                |            |        |           |          |         |              |              |             |          |           |             |              |          |                 |              |       |
| 60             | 25.64 0.00 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 |                |            |        |           |          |         |              |              |             |          |           |             |              |          |                 |              |       |
| 61             | 9.10 0.00 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 |                |            |        |           |          |         |              |              |             |          |           |             |              |          |                 |              |       |
| 62             | 0 0.00 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 |                |            |        |           |          |         |              |              |             |          |           |             |              |          |                 |              |       |
| 63             | 0 0.00 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 |                |            |        |           |          |         |              |              |             |          |           |             |              |          |                 |              |       |
| 64             | 0 0.00 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 |                |            |        |           |          |         |              |              |             |          |           |             |              |          |                 |              |       |
| 65             | 0 0.00 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 |                |            |        |           |          |         |              |              |             |          |           |             |              |          |                 |              |       |
| 66             | 0 0.00 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 |                |            |        |           |          |         |              |              |             |          |           |             |              |          |                 |              |       |