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Analysis of Plant Species Community within Upland Wetlands at Mt. Ilgwang

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Abstract

This study characterized the full range of vegetation in a upland wetland (marshland) in Korea. Classified community types were used to describe vegetation at the marshland and adjacent areas. The communities contained 44 species of vascular plants and all species were identified into four plant community types. The *Rhododendron yedoense* f. *poukhanense* type and *Lespedeza cyrtobotrya* type had a high representation infacultative upland species (FU) and obligate upland species (OU), respectively. The monocot type was dominant in marshland by *Miscanthuns sacchariflorus* and contained 14 species. Together the three areas contained four species, with the strongest indicator species being *Ranunculus acris* var. *nipponicus, Rhododendron yedoense* f. *poukhanense*, *Hemerocallis fulva*, and *Miscanthuns sinensis* var. *purpurascens*. Shannon-Weaver index of diversity also varied among the community types (F = 18.9, df = 2), with the types FU having significantly higher value (3.467) than the others (1.125 for type FW and 1.239 for type OU).

Key Words : Cluster analysis, Community types, Wetlands

1. Introduction

Wetlands are the link between land and water. Some common names for different types of wetlands are swamp, marsh, and bog. Depending on the type of wetland it may be filled mostly with trees, grasses, shrubs or moss. To be called a wetland, an area must be filled or soaked with water at least part of the year (Brooks et al., 1998). The definition often used by Canadian scientists is: A wetland is land that is saturated with water long enough to promote wetland or aquatic processes as indicated by poorly drained soils, hydrophytic vegetation and various kinds of biological activity which are adapted to a wet environment (Tarnocai, 1989).

The small wetlands can contribute disproportionately to landscape-level diversity because they often have high levels of both local species richness (alpha diversity) and spatial variation in community composition (beta diversity) (Wright et al., 2002; Williams et al., 2004; de Meester et al., 2005). In addition, wet habitat patches surrounded by uplands may support distinctive species assemblages, different from those of large-scale wetlands (Colburn, 2004; Nicolet et al., 2004; de Meester et al., 2005). These communities often include regionally rare species, and they can serve as refugia for wetland specialists in landscapes where major wetlands are destroyed, degraded, or absent (Nicolet et al., 2004; Williams et al., 2004). As human activities such as pollution and drainage continue to threaten small isolated wetlands, it is critical to make a full assessment of their conservation value (Tiner, 2003).

Wetland habitats are both abundant and widely varied, including permanent and seasonal ponds,

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glades, stream banks, and other small wetlands (Brooks et al., 1998). However, despite the abundance and ecological importance of wetlands within forested landscapes, many aspects of their biology remain unknown (Palik et al., 2003). The plant communities of forest wetlands in Korea are no exception. A few previous studies of the plant communities of wetlands in Korea have only focused on the lists of plant and animal species. However, these wetlands often defy simple classification (Colburn, 2004); the distinctions among wetland types remain largely arbitrary and inconsistent, and the floras of different wetland features in a landscape often substantially overlap.

Wetlands throughout upland regions of Korea, already reduced by over 50 percent by development pressures, are now being further degraded by mountain-climbers, the invasion of foreign species. The 8.4 km^2 natural areas per year in Korea are converted to graveyards. It is serous to make personal graveyards and public memorial parks in a forest fields. Especially, it is very good cemeteries because wetlands upland regions are flat and located in forests.

The Yangsan and Ilkwang provinces in Busan, Korea are fortunate to have many small local wetlands (Fig. 1). This study characterized the full range of wetland vegetation in a new upland forest (marshy land) at Mt. Ilgwang, Gijang-gun. Specifically, I assessed community composition among assemblages, a classification of wetland vegetation types, and species diversity.

2. Materials and methods

2.1. Sites

The study area is located at Mt. Ilgwang, Gijang-gun, South Korea (Fig. 1). The geographical location is 129° 08' 35"E, 35° 17' 32"N. The mountain has a diversity of vegetation, most dominated by pine, oak, and alder. The wetland ranges from 280 m to 320 m. I sampled all the vascular plants within 180 m x 120 m area.

2.2. Community analysis

The identification of characteristic or indicator species is criticized the Reed's classification (Reed, 1988). He describes species "probability of occurrence in wetlands" as opposed to upland habitats, with obligate wetland species having a percentage probability of occurrence in wetlands (OU) >99; facultative wetland species (FW), 67-99; facultative species (F), 34-66; facultative upland species (FU), 1-33; and obligate upland species (OU), <1. To

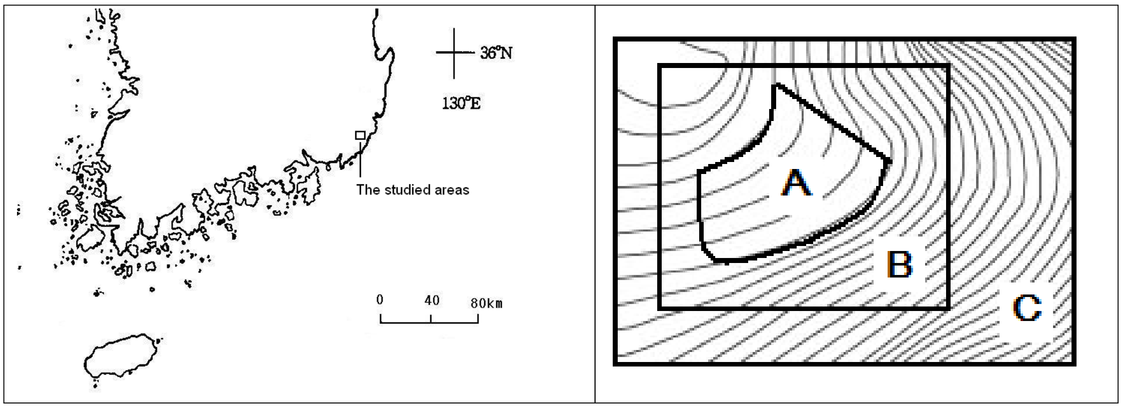

Fig. 1. The location of new wetland and the environs.
A: The new inland wetland. B: 100 m x 80 m areas (except A). C: 180 m x 120 m areas (except B).

define groups of plant community, I first conducted a hierarchical, agglomerative cluster analysis with Sørensen (Bray-Curtis) similarities based on percentage cover classes, using the flexible beta linkage method with $\beta = -.25$ in the program PC-ORD (McCune and Mefford, 1999; Flinn et al., 2008). I then used the indicator species analysis of Dufrêne and Legendre (Dufrêne and Legendre, 1997) to choose an appropriate number of groups from the cluster analysis and to describe the resulting community types. This method calculates indicator values for each species in each group as the product of the species'mean abundance in that group relative to other groups and the proportion of areas in that group where it is present (Flinn et al., 2008). By comparing the results of indicator species analysis at multiple levels of clustering, I chose the minimum number of groups that maximized the average significance of indicator values and the number of species with significant indicator values (McCune and Mefford, 1999; Rees et al., 2004). The Shannon-Weaver index of diversity was used to characterize species richness and abundance (Weaver and Kellman, 1981).

2.3. Soil analysis

I quantified total N and P concentrations for soil and leaves at three areas, new inland wetland (A), 100 m x 80 m areas (B), and 180 m x 120 m areas (C).

3. Results

The communities of three areas (A, B, and C) on Mt. Ilgwang contained 44 species of vascular plants (Table 1). These included many species listed as threatened or rare in Korea. The values of plant species for four types of plant communities were from 0 (no indication) to 100 (perfect indication, i.e., the species is always present in that community type and never present in others).

From the cluster analysis, 44 species were identified into four plant community types (Fig. 2). This level of grouping retained about 56.2% of the information in the dendrogram. Overall, pairwise comparisons showed significant differences in species composition among all groups (overall $t = -37.4$, $P < 0.0001$, chance-corrected within-group agreement $A = 0.13$).

The *Rhododendron yedoense* f. *poukhanense* type and *Lespedeza cyrtobotrya* type had high in facultative upland species (FU) and obligate upland species (OU), respectively. This type was shrubs and had greater cover that in the other types. The *Utricularia yakusimensis* type had the highest proportions of obligate wetland species (OW) (Fig. 3). They contain four insectivorous species, *Drosera rotundifolia,* *Utricularia bifida*, *Utricularia yakusimensis*, and *Utricularia racemosa.* The monocot type was dominated in marshland by *Miscanthuns sacchariflоruc* and contained 14 species.

Together the three areas contained four species, with the strongest indicator species being *Ranunculus acris* var. *nipponicus, Rhododendron yedoense* f. *poukhanense*, *Hemerocallis fulva*, and *Miscanthuns sinensis* var. *purpurascens*. Shannon-Weaver index of diversity also varied among the community types ($F = 18.9$, $df = 2$), with the types FU having significantly higher value (3.467) than the others (1.125 for type FW and 1.239 for type OU). Regional plans including all of the diverse types of wetland vegetation in upland forests will contribute substantially to the conservation of plant diversity.

Wetlands were shown with the relative individual density or abundance across areas. Area A had high number of species as well as those of both area, B and C. Shannon-Weaver index of diversity also varied among the areas with the areas B (2.323) and

Table 1. Indicator values of plant species for four types of wetland communities on Gijang-gun, Korea. The values range from 0 (no indication) to 100 (perfect indication, i.e., the species is always present in that community type and never present in others)

Code	Species	Community type			
		Lc	Rm	Ur	Ms
L-①	*Hololeion maximowiczii* Kitamura	60	2	11	1
L-②	*Salix gracilistyla* Miq.	57	0	3	3
L-③	*Asarum maculatum* Nakai	24	5	1	2
L-④	*Asarum sieboldii* Miq. var. *seoulensis* Nakai	23	8	0	2
L-⑤	*Ranunculus acris* Lenne var. *nipponicus* Hara	44	14	12	2
L-⑥	*Hepatica asiatica* Nakai	56	8	0	1
L-⑦	*Thalictrum raphanorhizon* Nakai	23	2	4	2
L-⑧	*Caltha palustris* var. *nipponica* Hara	2	22	0	1
L-⑨	*Rubus lodhamii* Miq	66	0	0	3
L-⑩	*Lespedeza cuneata* G. Don	61	9	0	0
L-⑪	*Lespedeza cyrtobotrya* Miq.	45	21	0	0
L-⑫	*Lespedeza maximowiczii* Schneid.	40	7	2	0
R-①	*Rhus tichocarpa* Stokes	11	32	0	0
R-②	*Tripterygium regelii S*prague et Takeda	0	10	0	0
R-③	*Rhododendron mucronulatum* Turcz.	0	13	0	0
R-④	*Rhododendron yedoense* f. *poukhanense* (Lev.) Nakai	6	15	11	0
R-⑤	*Primula modesta* Bisset et Morren	8	44	5	0
R-⑥	*Primula sieboldii* Morren	6	18	0	0
R-⑦	*Gentiana scabra* var. *buergeri* (Miq.) Max.	0	3	2	0
R-⑧	*Swertia tetrapetala* Pallas	0	5	0	0
R-⑨	*Plantago asiatica* L.	0	11	0	0
R-⑩	*Patrinia scabiosaefolia* Fisch.	0	24	0	0
R-⑪	*Valeriana fauriei* Briqeet	0	10	0	0
R-⑫	*Platycodon grandiflorum* (Jacq.) A. DC.	6	15	0	0
R-⑬	*Solidago virga-aurea* var. *asiatica* Nakai	7	10	0	0
R-⑭	*Clinopodium gracile* var. *multicaule* (Max.) Ohwi	0	4	0	0
U-①	*Drosera rotundifolia* L.	0	0	30	0
U-②	*Utricularia bifida* L.	0	0	54	0
U-③	*Utricularia yakusimensis* Masam.	0	0	70	0
U-④	*Utricularia racemosa* Wall.	0	0	66	0
M-①	*Arthraxon hispidus* (Thunb.) Makino	2	0	0	12
M-②	*Miscanthuns sinensis* var. *purpurascens* Rendle	3	4	0	20
M-③	*Miscanthus saccharifloruc* Benth.	0	6	0	23
M-④	*Carex humilis* var. *nana* Leyss	12	9	0	15
M-⑤	*Juncus effusus* var. *decipiens* Buchen.	0	1	0	7
M-⑥	*Scirpus wichurae* Böcklr	2	3	0	9
M-⑦	*Phragmites communis* Trin.	0	2	0	6
M-⑧	*Molinia japonica* Hack	0	0	0	2
M-⑨	*Hemerocallis fulva* L.	1	6	0	11
M-⑩	*Lilium concolor* Slisb.	0	2	0	3
M-⑪	*Smilax china* L.	0	4	0	7
M-⑫	*Tulotis ussuriensis* (Regel et Maack) Hara	0	3	0	8
M-⑬	*Platanthera hologlottis* Maxim	0	1	0	5
M-⑭	*Cypriopedium macranthum* Swartz	1	5	0	12

Notes: The community types are named for the species with the highest indicator value, abbreviated as Lc, *Lespedeza cuneata* Rm, *Rhododendron mucronulatum* Ur, *Utricularia racemosa* and Ms, *Miscanthus saccharifloruc*. The indicator values combine species' relative frequency and relative abundance across groups, expressed as percentages of perfect indication[13]. For each species in each community type, the indicator value is the product of the species mean abundance in that type relative to other types and the proportion of areas in that type where it is present.

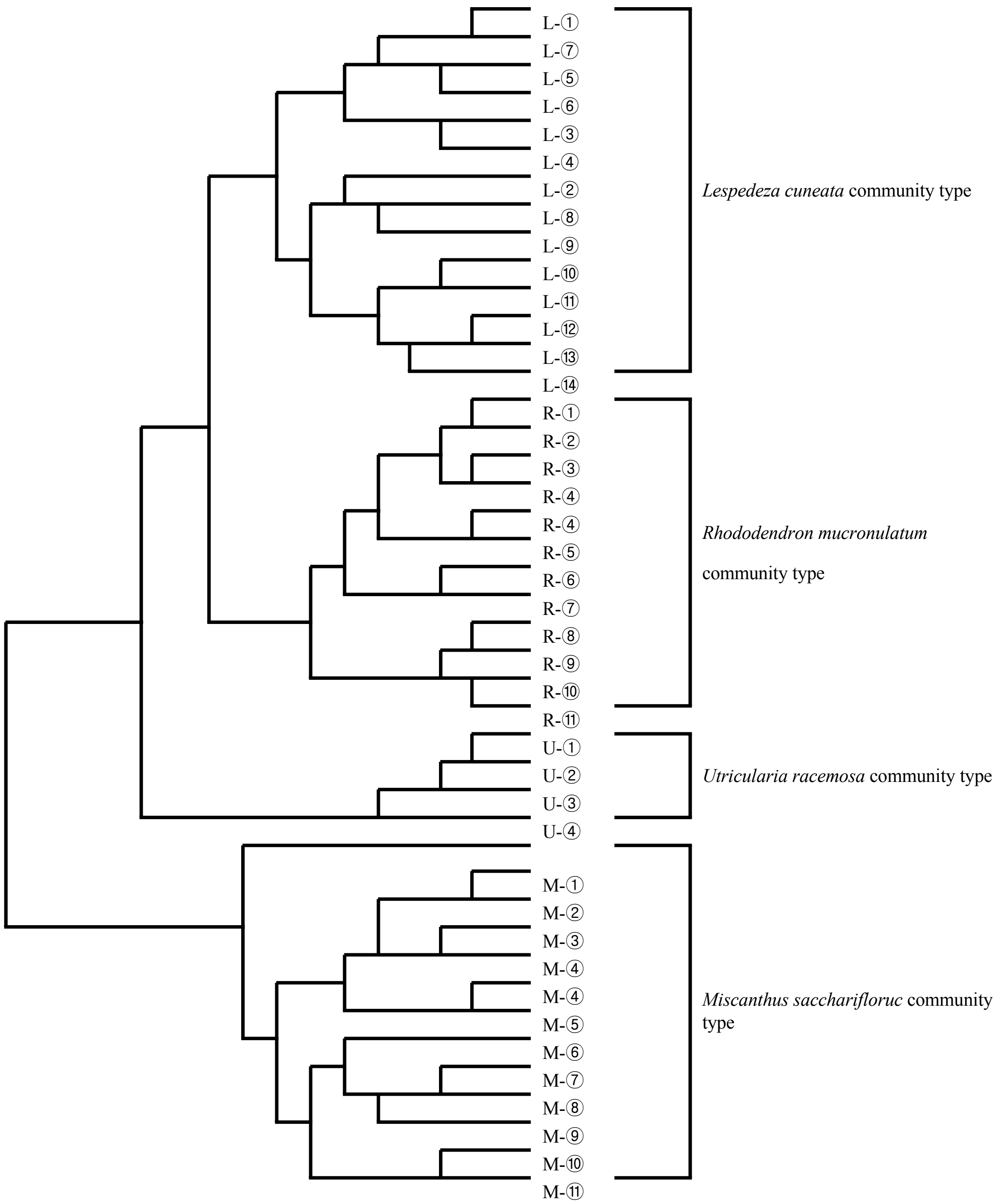

Fig. 2. Dendrogram of the results of hierarchical, agglomerative cluster analysis, grouping 44 wetland species into four community types, named for the species with the highest indicator value.

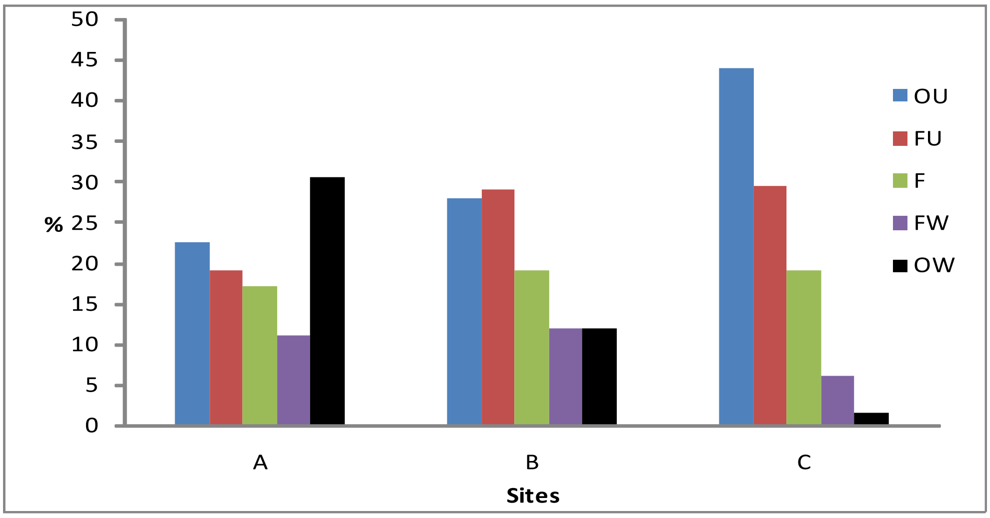

Fig. 3. Histograms showing the proportions of the plant species in five types of wetland communities, named for the species with the highest indicator value, that belong to each National Wetlands Inventory indicator category. Categories include OU, obligate upland species; FU, facultative upland species; F, facultative species; FW, facultative wetland species; and OW, obligate wetland species. A, B, and C are the same as Fig. 1.

C (2.415) having higher value than the wetland area A (2.179).

There were evaluated differences in final nutrient content (Table 2). Although the mean carbon concentration for area C was slightly greater than areas A and B, it was not significance ($P<0.05$). The Final N and P concentrations for area A are 0.023 and 0.001, which are significantly lower than those for areas B and C.

Table 2. The mass of total C, N, and P at three areas

Chemicals	Areas	Mean (SD)
Mass C (g/Kg)	A	1.994 (0.006)
	B	2.083 (0.012)
	C	2.112 (0.015)
Mass N (g/Kg)	A	0.021 (0.004)
	B	0.028 (0.003)
	C	0.030 (0.005)
Mass P (mg/Kg)	A	0.001 (0.0)
	B	0.002 (0.0)
	C	0.002 (0.0)

4. Discussion

The wetlands and wetland complexes maintain a unique biological diversity and are characterized by a high level of plant and animal endemism (Keiper et al., 2002). However our results are plant species is so complicated and animal species is not more diverse (data not shown). They are also shelters and breeding zones for a great number of species with conservation problems, particularly the fauna, such as the four insectivorous species, *Drosera rotundifolia, Utricularia bifida*, *Utricularia yakusimensis*, and *Utricularia racemosa,* and three orchids, *Tulotis ussuriensis, Platanthera hologlottis,* and *Cypriopedium macranthum.* In addition, these species are listed as threatened or rare taxa in Korea. Thus, the new marshy landis very important implications for the academic information and management of conservation.

Wet places cover a very small proportion of the landscape at Mt. Ilgwang, Busan. Small and surrounded by upland forests, the wet areas in this study contained as many upland species as wetland species. At the same time, wet places on Mt. Ilgwang provided habitat for many wetland plants that would not otherwise occur in an upland forest landscape.

30.2% of the species in this new wetland was obligate wetland species, 11.6% facultative wetland species, 16.3% facultative species, and 18.6% obligate upland species. It is similar to the American National Wetlands Inventory classification (Reed, 1988).

Taxon richness is a major component of biological diversity and an important ecosystem characteristic (Chapin et al., 2002; Dowing and Leibold, 2002). The wet places on Mt. Ilkwang revealed a broad gradient in N:P supply ratios but highly constrained producer stoichiometry. The differential accumulation or loss of carbon and nutrients during decomposition can promote differentiation of wetland ecosystems, and contribute to landscape-scale heterogeneity (Troxler and Childers, 2009).

This study has several important implications for the design and management of reserves and other forest lands. First, it demonstrates that wetlands within upland forests are indeed rare in Korea. Thus the three high wetlands are valuable resource for the conservation of plant diversity and academic research. Second, they are lying areas where enough water collects to support water-loving plants. Wetlands include the area covered by water and the adjacent area of lush water-loving plants. This has increased the amount of soil moisture available for crop and forage production. Third, though animal species are not diverse, wetlands provide great volumes of food that attract many animal species. These animals use wetlands for part of or all of their life-cycle. Dead plant leaves and stems break down in the water to form small particles of organic material called "detritus." This enriched material feeds many small aquatic insects and amphibians that are food for larger predatory reptiles, birds, and mammals.

Continuing human population growth will be bring on continued alteration of natural ecosystems and the evitable loss of more wetlands if the culture of burial in Korea is not changed. It is endangered because Busan City has a plan to construct a mountain trail near the studied regions.

5. Conclusions

The *Rhododendron yedoense* f. *poukhanense* type and *Lespedeza cyrtobotrya* type had a high representation infacultative upland species (FU) and obligate upland species (OU), respectively. The monocot type was dominant in marshland by *Miscanthuns sacchariflоruc*. The communities of three areas (A, B, and C) on Mt. Ilgwang contained 44 species of vascular plants. These included many species listed as threatened or rare in Korea. Although multiple causes are usually the rule in loss of biodiversity, the greatest loss (total 44 species) is caused by the artificial alteration of habitats through the construction of the public memorial park within one year.

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