RIVER ECOSYSTEM AND FLORISTIC COMPOSITION OF RIPARIAN ZONES AT THE UNAM RIVER, UIRYEONG-GUN, KOREA

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ABSTRACT

This study is examined river naturality and vegetative composition of river riparian zones to identify their most important sources of variation. Information on plant species and on physical characteristics that occur at the A region, B region, and C region was collected for 30 riparian plots located throughout the Unam River in Korea. According to the existing phytosociological data, 23 families, 57 genera, 66 species, 9 varieties have been identified. The vegetation of low water's edge was natural weeds, shrubs, and mixed. The vegetation of flood way was various (both of natural vegetation and artificial vegetation at the A region, artificial vegetation with parks, lawns, and so on at the B region, and artificial vegetation at the C region). The value of cover-abundance at the A region was total 12.4 and cover-abundance values of grasses and forbs were 2.33 and 2.04, respectively. A Shannon-Weaver index (H´) of diversity at the A region was 3.48 across growth forms, varying from 0.59 to 3.01. The total richness index at the A region was 7.92. Although evenness indices were different from each other, there were not shown significant differences ($p < 0.05$). Recent, many riparian areas of this river have been lost or degraded for commercial and industrial developments. Thus, monitoring for biological diversity of plant species of this river is necessary for an adaptive management approach and the successful implementation of ecosystem management.

Keywords: Cover-abundance, riparian vegetation, river naturality, Unam River.

INTRODUCTION

Introduction should be given in this section. Font Size 12, Times New Roman, single spaced. All the subheadings in this section should be in font size 12 Bold, Times New Roman, single spaced. The first letter of each word in subheading should be capital. The structure of a floodplain river reach is determined over a long period of time. However, small-scale features such as individual islands, side channels, and backwaters change more frequently. Natural resource problems within the agriculture fields are caused by many natural and human-related factors or events. Average stream flow, flow variability, velocity, stream morphology, and water quality gradually change along longitudinal stream gradients. The size and structure of floodplain rivers change along their length as a result of natural fluvial processes and human activity.

River bank vegetation, ecologically termed as riparian flora which are defined as "transitional areas between terrestrial and aquatic ecosystems and are distinguished by gradients in biophysical conditions, ecological processes, and biota (Dutta et al., 2011).

Riparian wetlands, deltas and estuaries are normally seen as highly productive systems that harbour a high number of plant species (Nilsson and Berggren, 2000). It has long been recognized that riparian zones perform important services, including improvement of surface and groundwater quality, provision of high quality habitat, reduction of flood risk and erosion, and increased stabilization of banks (Merrill et al., 2006). Thus, riparian vegetation is increasingly being recognized for its importance in influencing the hydrology and morphology of fluvial systems (Tooth and Nanson, 1999).

Vegetative density, biomass, production, and species distributions also exhibit patterns within sites, among sites, within regions and between regions. The many plants that grow along the banks of this river and her tributaries play an important role in the diverse ecosystems the river supports. Not only do the plants rely on the Unam River for water, but they also play an important role in nutrient and water conservation, and their presence controls soil erosion along the banks. Riparian zones of upper regions in the Unam River have been destructed to construct reservoirs. Riparian zones of middle and low regions in the Unam River have been destructed to use agricultural fields. This disrupts the natural flooding cycles, reduces flows, drains wetlands, cuts rivers off from their floodplains, and inundates riparian habitats, resulting in the destruction of species, the intensification of floods and a threat to livelihoods in the long term (Lowe and Likens, 2005).

The purpose of this study is to investigate river ecosystem and the flora on the Unam River at three regions. Therefore, this survey gathered from this study provides an increasing understanding of the floristic analysis of Unam River riparian floodplains, which can be used to guide management and improvement of the riverine environment in the river.

METHODOLOGY

Surveyed Regions

This study was carried out on the Unam River (upper region: 35°358′246″N/128°222′337″E, low region: 35°329′149″N/128°224′912″E), located at Uiryeong province in Korea (Fig. 1). The river is located to the northern east of the city of Uiryeong-gun. The river is approximately 2.75 kilometers in length with a varying width of between 2.0 and 28.5 meters. The flora and vegetation on the Unam River were investigated at two upper regions and one low region during four seasons. The upper area of the Unam River, including one reservoir per region, used to be covered with moderate deciduous forest made up of pine trees and other species. Unfortunately, deforestation of the middle and low regions accelerated significantly between 1980 and 1990.

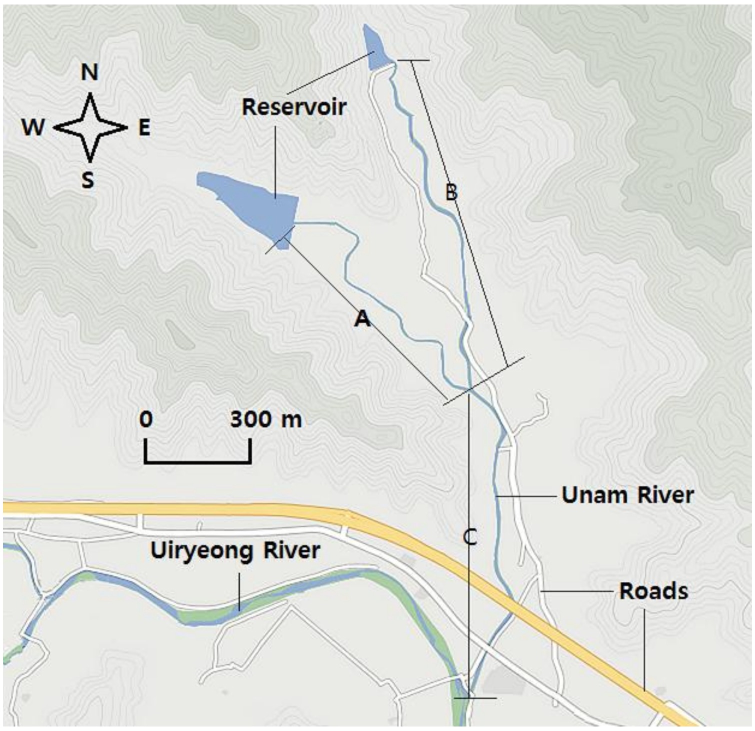

Fig. 1. Location of the study area and the three detailed internodes at the Unam River.

Floristic analysis

Sampling with quadrats (plots of a standard size) can be used for most plant communities (Cox, 1990). Three sectors of the riparian vegetation on the Unam River were chosen to study. The following floristic parameters were recorded within each of the quadrats: all plant taxa, identifiable at the time of sampling, rooted in the stand, a growth form (tree, shrub, grass and forb) was assigned to each species recorded following Westfall (1992). A quadrat delimits an area in which vegetation cover can be estimated, plants counted, or species listed. Quadrats were established randomly, regularly, or subjectively within a study site since plants often grow in clumps, long, narrow plots often include more species than square or round plots of equal area. Each species was collected, mounted, labeled, and systematically arranged in a herbarium. The system of plant classification system was followed by Lee (2007). Naturalized plants were followed by Korea National Arboretum (2012). Abundance and cover degree are usually estimated together in a single combined estimation or cover-abundance scale from Braun-Blanquet (1964). In order to relate the model to the field situation in which usually Braun-Blanquet figures are recorded, the % occupancy figures were transformed in to the ordinal transform scale from 1 (one or few individuals) to 9 (75~100% cover of total plot area, irrespective of number of individuals) (Dietvorst et al., 1982). The relative net contribution degree (r-NCD) was obtained by summing up the NCD values for those species belonging to particular taxa under consideration (Kim, 1996).

Index of degree of river structure

The three regions of Unam River were divided by the geographic location with considering length of the river and river morphology. Index of degree of river naturality according to the environment of river was also analyzed according to Table 1. River terminology was followed by Hutchinson (1975). The test for biochemical oxygen demand (BOD) is a bioassay procedure that measures the oxygen consumed by bacteria from the decomposition of organic matter (Sawyer and McCarty, 1978). The method for BOD was used to a standard method of the American Public Health Association (APHA) and is approved by the U.S. Environmental Protection Agency (2002).

Biotic Indices

Shannon–Weaver index of diversity (Shannon and Weaver, 1963): the formula for calculating the Shannon diversity index (H') is

$$H' = -\Sigma\, pi \ln pi$$

*p*i is the proportion of important value of the *i*th species (*p*i = *n*i / N, *n*i is the important value index of *i*th species and N is the important value index of all the species).

$$N = e^{H'}$$

The species richness of animals was calculated by using the method, Margalef's index (R) of richness (Magurran, 1988).

$$R = (S\text{-}1)/\mathrm{In}(n)$$

S is the total number of species in a community and *n* is the total number of individuals observed. Evenness index was calculated using important value index of species (Hill, 1973; Pielou, 1966).

$$E = H'/\mathrm{In}(S)$$

RESULTS

A region

The river width at this region is about 2.55 m. The vegetation of low water's edge was natural weeds, shrubs, and mixed (Table 2). The vegetation of flood way was both of natural vegetation and artificial vegetation. Land use in riparian zones was arable land or artificial vegetation. Land uses of flood plains beyond river levee were arable land or artificial vegetation. Transverse direction of artificial structures was one reservoir. The average value of BOD was 2.47 mg/l. The oxygen-demand parameter BOD at upper region was relative clear. The ratio of sleep width/river width was 5-10%. The value for index of degree of river naturality according to the environment factors was a mean of 2.286. Riparian vegetation provides habitat for many wildlife species (Table 3). At total area, the application of the Braun-Blanquet approach for plant classification in this area is presented in the article. According to the existing phytosociological data, 23 families, 57 genera, 66 species, 9 varieties have been identified. Transition zones of this section were distributed pine vegetation. Although the river width was relative large and the depth of water was swallow, distributions of aquatic plants did not developed in riparian. The dominant species (according to cover and frequency) that occur in the A region are *Equisetum arvense* and *Pinus **thunbergii***. Dominant species in flood plains was *Phragmites japonica*. The survey region was a total of 36 taxa, including 18 families, 33 species, and three varieties. Naturalized plants were eleven species. The total transformed Braun-Blanquet value and r-NCD at upper area were 83 and 1,037.5, respectively. The value of cover-abundance was total 12.4 (Table 4). Cover-abundance values of grasses and forbs were 2.33 and 2.04, respectively. A Shannon-Weaver index (H´) of diversity was 3.48 across growth forms, varying from 0.59 to 3.01. The total richness index was 7.92. Although evenness indices were different from each other, there were not shown significant differences ($p < 0.05$).

B region

The river width at the region is about 2.0 m. The riparian areas of both the river banks are dominated by mixed sediment and the vegetation is composed of herbs, shrub, trees, climbers and macrophytes (Table 2). The vegetation of low water's edge was natural weeds, shrubs, and mixed. The flood way vegetation was artificial vegetation with parks, lawns, and so on. Land uses in riparian zones river levee were bush or grassland as natural floodplain. Land use in flood plains beyond river levee was arable and artificial vegetation. Land uses of flood plains beyond river levee were arable land or artificial vegetation. Transverse direction of artificial structures was bypass reservoir or slope waterway reservoir. The average value of BOD was 2.81 mg/l. The oxygen-demand parameter BOD was relative clear. The ratio of sleep width/river width was 5-10%. The value for index of degree of river naturality according to the environment factors was a mean of 2.429. Left and right riparian areas were distributed Gramineae vegetation (12 taxa including *Miscanthus sinensis* var. *purpurascens*) (Table 3). Other phyla were occasionally recorded in low densities. Riverbed area was dominated by the distribution of the willow (*Salix gracilistyla*) and Onagraceae (*Oenothera odorata*). Land use in flood plains beyond river levee was dominated Cruciferae vegetation (*Capsella bursa-pastoris*). The survey region was a total of 47 taxa, including 19 families, 42 species, and 5 varieties. Naturalized plants were 15 species. The total transformed Braun-Blanquet value and r-NCD at middle area were 101 and 1,263, respectively. The value of cover-abundance was total 11.38 (Table 4). A Shannon-Weaver index (H´) of diversity was 3.73 across growth forms, varying from 0.35 to 3.21. For the community as a whole, richness and evenness of trees were very low (0.46 and 0.50).

C region

The river width at the region was about 28.5 m. The vegetation of low water's edge was natural weeds, shrubs, and mixed (Table 2). The flood way vegetation was removed artificial vegetation. Land uses of flood plains beyond river levee were arable land or artificial vegetation. Land use in flood plains beyond river levee was artificial vegetation or natural vegetation mixed. Transverse direction of artificial structures was one that fish move completely blocked. The average value of BOD was 3.15 mg/l. The oxygen-demand parameter BOD was within acceptable levels. The ratio of sleep width/river width was 1-5%. The value for index of degree of river naturality according to the environment factors was a mean of 3.286. The left and right areas in flood plains beyond river were roads and residential villages. Riverbed area was dominated by the distribution of the Chenopodiaceae communities (Table 3). They dominated over the other phyla and were mainly recorded in high densities during summer and autumn. The survey region was a total of 47 taxa, including 18 families, 41 species, and 6 varieties. Naturalized plants were 22 species. The total transformed Braun-Blanquet value and r-NCD at middle area were 101 and 1,262.5, respectively. The value of cover-abundance was total 9.85 (Table 4). A Shannon-Weaver index (H´) of diversity was 3.86 across growth forms, varying from 0.56 to 2.84. For the community as a whole, richness of trees was very low (0.72).

Table 1. Index of degree of river naturality according to the environmental factors

Item	Estimated index and scores				
	1	2	3	4	5
The low water's edge vegetation	Naturally formed a variety of vegetation communities	Naturally formed various vegetation communities by natural erosion (sediment exposure) were absent	Natural weeds, shrubs, and mixed	Artificial vegetation composition	Vegetation blocked by stonework etc.
Flood way vegetation	Naturally formed a variety of vegetation communities	Naturally formed various vegetation communities by natural erosion (sand bar) were absent	Both of natural vegetation and artificial vegetation	Artificial vegetation with Parks, lawns, and so on	Remove vegetation artificially
Land use in riparian zones within river levee	Bush or grassland as natural floodplain	Arable land (paddy fields, orchards)	Arable land, urban, residential mixed	About 1/2 urban, residential mixed	1/2 or more urban, residential
Land use in flood plains beyond river levee	State of nature without artificial vegetation, manmade structures	Arable land or artificial vegetation	Artificial vegetation or natural vegetation mixed	About 1/2 park facilities, playground facilities	Impervious man-made structures, parking, etc.
Transverse direction of artificial structures	Absent	Bypass reservoir or slope waterway reservoir	Fish migration reservoir	Reservoir of height 0.3-0.4 m, fish migration difficulty	Fish move completely blocked
Water quality (BOD)	Class 1 (crystal clear)	Class 2 (clear relatively)	Class 3 (tan, the bottom green algae)	Class 4 (blackish brown, the floor is not looked)	Class 5 (an ink color, odor)
Sleep width /river width ratio	20% or more	20 ~ 10%	10 ~ 5%	5 ~ 1 %	Less than 1%

Table 2. The degrees of river naturality according to the environmental factors at the Unam River

Region	The low water's edge vegetation	Flood way vegetation	Land use in riparian zones within river levee	Land use in flood plains beyond river levee	Transverse direction of artificial structures	Water quality (BOD)	Sleep width /river width ratio	Mean
A	3	3	2	2	1	2	3	2.286
B	3	4	1	2	2	2	3	2.429
C	3	5	2	3	4	2	4	3.286

Table 3. List of vascular plants, Braun-Blanquet's score, and r-NCD at three regions of the Unam River

Family	Species	Region			Invaded plant	r-NCD		
		A	B	C		A	B	C
Equisetaceae	*Equisetum arvense* L.	4	2	4		50.0	25.0	50.0
Ginkoaceae	*Ginko biloba* L.			1				12.5
Pinaceae	*Pinus densiflora* S. et Z.	3	1			37.5	12.5	
	*Pinus **thunbergii*** Parl.	8	8			100.0	100.0	
Salicaceae	*Salix gracilistyla* Miq.		3	2			37.5	25.0
Moraceae	*Morus alba* L.			4				12.5
Cannabinaceae	*Humulus japonicus* S. et Z.	3	3			37.5	37.5	
Polygonaceae	*Persicaria blumei* Gross		2	1			25.0	12.5
	Persicaria hydropoper (L.) Spach.	2				25.0		
	Persicaria sieboldi Ohki		1				12.5	
	Persicaria thunbergii H. Gross	2				25.0		
	Rumex acetocella L.		3	2	NAT		37.5	25.0
	Rumex acetosa L.	2				25.0		
	Rumex conglomeratus Murr.		2	2	NAT		25.0	25.0
	Rumex crispus L.	2	2	3	NAT	25.0	25.0	37.5
Chenopodiaceae	*Chenopodium album* var. *centrorubrum* Makino	2	2	2		25.0	25.0	25.0
	Chenopodium ficifolium Smith			2	NAT			25.0
	Chenopodium glaucum L.			3				37.5
Amaranthaceae	*Achyranthes japonica* (Miq.) Pa.			3				37.5
	Amaranthus lividus L.		2		NAT		25.0	
	Amaranthus patulus Bertoloni	2	2			25.0	25.0	
Phytolaccaceae	*Phytolacca americana* L.		1	2	NAT		12.5	25.0
Cruciferae	*Capsella bursa-pastoris* (L.) Medicus		4				50.0	
	Capsella flexuosa With.	2		2		25.0		25.0
	Lepidium apetalum Willd.			3	NAT			37.5
	Lepidium virginicum L.			2	NAT			25.0

	Thlaspi arvense L.			3	NAT			37.5
Rosaceae	*Duchesnea chrysantha* (Zoll. Et Morr) Miq.	3	2			37.5	25.0	
	Potentilla fragarioides var. *major* Max.	2	2	3		25.0	25.0	37.5
	Prunus serrulata var. *spontanea* (Max.) Wils.			3				37.5
Leguminosae	*Amorpha fruticosa* L.			2	NAT			25.0
	Astragalus sinicus L.	1	1		NAT	12.5	12.5	
	Kummerowia striata (Thunb.) Schindl.	2	2	2		25.0	25.0	25.0
	Trifolium pratense L.	2		2	NAT	25.0		25.0
	Trifolium repens L.	2	2	2	NAT	25.0	25.0	25.0
	Vicia villosa Roth.	1	2	2	NAT	12.5	25.0	25.0
Oxalidaceae	*Oxalis corniculata* L.	3		2		37.5		25.0
	Oxalis stricta L.			2				25.0
Violaceae	*Viola mandshurica* W. Becker	3	4			37.5	50.0	
Onagraceae	*Oenothera odorata* Jacq.	2	5	4	NAT	25.0	62.6	50.0
Umbelliferae	*Oenanthe javanica* (Bl.) DC.	1	1			25.0	25.0	25.0
Oleaceae	*Forsythia koreana* Nakai			1				25.0
Plantaginaceae	*Plantago asiatica* L.	2	2	1		25.0	25.0	12.5
	Plantago laceolata L.			2	NAT			25.0
Caprifoliaceae	*Lonicera japonica* Thunb.	2	2			25.0	25.0	
Compositae	*Ambrosia artemisiifolia* var. *elatior* Descourtils			2	NAT			25.0
	Artemisia princeps Pampan.	2	2	2		25.0	25.0	25.0
	Aster ciliosus Kitamura		2				25.0	
	Bidens bipinnata L.			2				25.0
	Bidens frondosa L.	2		5	NAT	25.0		62.5
	Cirsium japonicum var. *ussuriense* Kitamura		2				25.0	
	Cosmos bipinnatus Cav.	3		3	NAT	37.5		37.5
	Conyza canadensis L.		2	2	NAT		25.0	25.0
	Erechtites hieracifolia Raf.			2	NAT			25.0
	Erigeron annuas (L.) Pers.		1	1	NAT		12.5	12.5
	Galingosa ciliate Blake	2	3		NAT	25.0	37.5	

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	Taraxacum officinale Weber			2	NAT			25.0
	Xanthium strumarium L.	2	2	2	NAT	25.0	25.0	25.0
Gramineae	*Agropyron tsukusinense* (Honda) Ohwi			1				12.5
	Alopecurus aequalis var. *amurensis* Ohwi.			4				50.0
	Avena fatua L.	2	2	2	NAT	25.0	25.0	25.0
	Argostis clavata var. *nukabo* Ohwi.		2				25.0	
	Beckmannia syzigachne (Steud.) Fern.	2				25.0		
	Bromus japonicus Thunb.		2				25.0	
	Cymbopogon tortilis var. *goeringii* Hand-Mazz.	2	2			25.0	25.0	
	Digitaria sanguinalis (L.) Scop.		2	4			25.0	50.0
	Echinochloa crus-galli (L.) Beauv.		1				12.5	
	Miscanthus sacchariflorus Benth.	1	1	3		12.5	12.5	37.5
	Miscanthus sinensis var. *purpurascens* Rendle		3	2			37.5	25.0
	Phragmites japonica Steud.		2	2			25.0	25.0
	Poa sphondylodes Trin.		1				12.5	
	Setaria viridis (L.) Beauv.		2	2			25.0	25.0
	Zoysia japonica Steud.	3	2	3		37.5	25.0	37.5
Cyperaceae	*Cyperus amuricus* Max	2	1	2		25.0	12.5	25.0
	Cyperus difformis L.	3	1	2		37.5	12.5	25.0
	Total	83	101	119		1,038	1,263	1,488

NAT: Naturalized plants.

Table 4. Mean cover-abundance of species and diversity indices at the Unam River

Growth form	No. species (%)	Mean cover-abundance of species	Diversity (H`)	Diversity (N)	Richness	Evenness
A region						
Trees	2 (5.6)	5.50	0.59	1.80	0.42	0.85
Shrubs	2 (5.6)	2.50	0.67	1.96	0.62	0.97
Grasses	9 (25.0)	2.33	2.14	8.47	2.36	0.97
Forbs	23 (63.9)	2.04	3.01	22.15	5.71	0.99
Total	36 (100)	12.40	3.48	32.56	7.92	0.97
B region						
Trees	2 (4.3)	4.50	0.35	1.42	0.46	0.50
Shrubs	3 (6.4)	3.00	1.09	2.97	0.87	0.99
Grasses	15 (31.9)	1.73	2.65	14.21	4.30	0.98
Forbs	27 (57.4)	2.15	3.21	24.79	6.40	0.97
Total	47 (100)	11.38	3.73	41.56	9.97	0.97
C region						
Trees	2 (3.9)	2.0	0.56	1.75	0.72	0.81
Shrubs	4 (7.8)	2.25	1.27	3.57	1.37	0.92
Grasses	15 (29.4)	2.40	2.63	13.88	3.91	0.97
Forbs	30 (58.8)	3.20	2.84	17.11	6.35	0.84
Total	51 (100)	9.85	3.86	47.64	10.46	0.98

DISCUSSION

In general, riparian plant communities are composed of specialized and disturbance-adapted species within a matrix of less specialized and less frequently disturbed upland forest (Fetherston et al. 1997). For a long time, natural riparian plants in Korea have been subject to human disturbances in which bringing under cultivation and exploiting are common. In spite of the important ecological role of water protection as shelter for associated fauna, in biodiversity conservation, and in the prevention of erosive processes for the region, riparian forests are continuously degraded by anthropogenic activities. This has occurred through illegal exploitation by farmers and other interest groups in extending agricultural areas.

An important goal for the management of riparian zones is to control diffuse pollution from agriculture. For example, the oxygen-demand parameter BOD was not good at low region (Table 2). T-N also has a significant influence at the low stream (Moon and Huh, 2016). They are important as pollutants in water system. Fertilizer supplies of N and P are the most important impacts on water quality. One of the most important impacts of N on the environment is that on water quality. Because N and P are frequently the nutrient most limiting biological productivity in estuaries (Vitousek et al., 1997), inputs of soil and fertilizer N from agricultural fields can be a major contributor to N-induced eutrophication.

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