

Flora and Species Diversity of Riparian Zones at Yongheung Stream, Hapcheon-Gun Province, Korea

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Abstract—The aim of this study was to analyze the flora and species diversity of Yongheung Stream, a small stream in Korea. The stream was divided into 3 compartments for convenience. Sampling with quadrats (plots of a standard size) can be used for most plant communities. The upper region was a total of 59 taxa, including 17 families, 47 genera, 52 species, and 7 varieties. Naturalized plants were 15 species. The total transformed Braun-Blanquet value and r-NCD at middle area were 162 and 1,800.0, respectively. The middle region was a total of 59 taxa, including 17 families, 47 genera, 52 species, and 7 varieties. Naturalized plants were 15 species. The total transformed Braun-Blanquet value and r-NCD at middle area were 162 and 1,800.0, respectively. Riverbed area was dominated by the distribution of three willow species (*Populus euramericana*, *Salix gracilistyla*, and *Salix koriyanagi*) at middle region. The low region was a total of 55 taxa, including 16 families, 43 genera, 47 species, and eight varieties. Naturalized plants were 20 species. The total transformed Braun-Blanquet value and r-NCD at middle area were 155 and 1,755.6, respectively. Invasion of natural ecosystems by exotic plant species is recognized as a major threat to biodiversity at Yongheung Stream.

Index Terms—Braun-Blanquet, Flora, Naturalized Plants, Yongheung Stream.

I. INTRODUCTION

The biologically distinctive area that borders the waterfront is called the riparian zone. *Riparian* came to English from the same source that gave us river - the Latin *riparius*, a noun deriving from *ripa*, meaning "bank" or "shore." First appearing in English in the 19th century, "riparian" refers to things that exist alongside a river (such as riparian wetlands, habitats, trees, etc.). A riparian has been defined as the area between the stream channel or near shore portion of a lake or pond and the furthest upland extent of the aquatic system's influence [1]. Diverse vegetation that grows along streams, rivers or reservoirs acts as a protective buffer between the land and the water. Retaining vegetation, including trees, within riparian areas is key to maintain functional linkages between terrestrial and aquatic ecosystems. Riparian areas have high plant diversity, both horizontally and vertically from the water's edge, which contributes to the high diversity of plants and animals that live in these areas.

Rivers provide many critical goods and services, including drinking water, agricultural water, power generation, nutrient recycling, organic matter retention, and

habitat for many plants and animals. Stream ecosystems are regulated by features and processes occurring at a range of spatial scales. Small headwater streams, where water first collects by runoff from the land or emerges from springs, are called first-order streams. When two first-order streams meet, they form a second-order stream; two of these converge to form a third-order stream, and so on [2].

Plant geographers have long recognized that plant species can be grouped on the basis of similarities among their geographic distributions [3]. The simplest floristic analysis is a list of names of plants occurring in a sample quadrat of a certain size (usually between 1 and 1,000 m²) in a homogeneous representative part of the vegetation to be described [4].

Yongheung Stream is started at the mountains. The most floodplains of the river have been converted to agricultural or horticultural fields, housing, restricting the river bed to a small channel. Although some plant collections were made in the jointed more big river, Sinjeon River, the total number of reported species was nor reported the number of plants that presently constitute the Sinjeon River and Yongheung Stream. Native or exotic plants are defined as grasses, shrubs, and trees that naturally or intentionally occur in the region, area, or biome in which they originally evolved. Several authors have used these terms in proposing schemes for conceptualizing the sequence of events from introduction to invasion, but often imprecisely, erroneously or in contradictory ways. The numbers of invasive species in various parts of the world continue to increase, representing a serious threat to biodiversity worldwide [5]. The awareness of the magnitude of problem is stimulating not only management efforts [6, 7, 8], but also research aimed at deeper understanding of underlying processes and determinants of naturalization and invasion [9]. The knowledge of ecological impacts on native biodiversity and ecosystem functioning is needed in Yongheung Stream.

The objective of this study was to provide flora and species diversity to riparian of Yongheung Stream, Hapcheon-gun, Gyeongsangnam-do province in Korea, from surveys of three areas. These included (1) upland, forest; (2) middle land riparian; and (3) lowland, riparian/riverbank communities. The results can be used to guide management and improvement of the riverine environment in the river.

II. MATERIALS AND METHODS

A. Surveyed Regions

This study was carried out on Yongheung Stream upper region: 35°39'564"N/128°16'024"E, low region: 35°39'8990"N/128°12'5'691"E), located at Hapcheon-gun, Gyeongsangnam-do province in Korea (Figures 1 and 2). The stream is approximately 4.5 kilometers in length with a

varying width of between 2.3 and 6.7 meters. The stream was divided into 3 compartments for convenience. The upper area of Yongheung Stream, including one reservoir, used to be covered with pine trees and other species. The middle region of the stream included one reservoir and flood plains of this area are usually very fertile agricultural areas. The low region was absent reservoirs and consisted of a mosaic of agricultural fields and farming houses. Mean annual temperature ranges from -0.5 (January) to 25.4 °C (August) with 13.0°C, and mean annual precipitation ranges from 15.2 (December) to 294.5 mm (August) with 1275.6 mm.

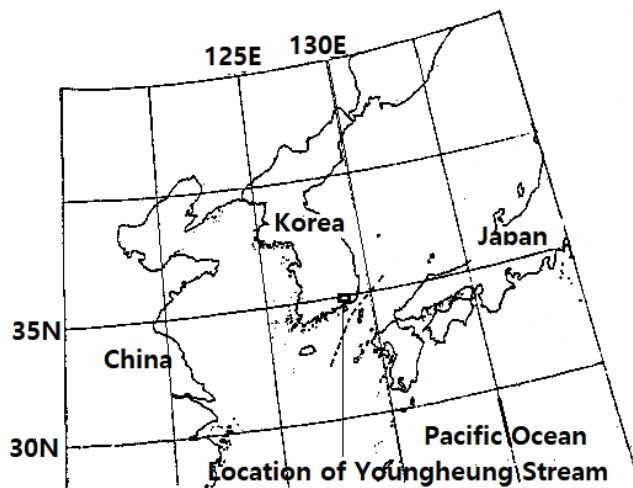


Fig. 1. Location of the study area at the Yongheung Stream.

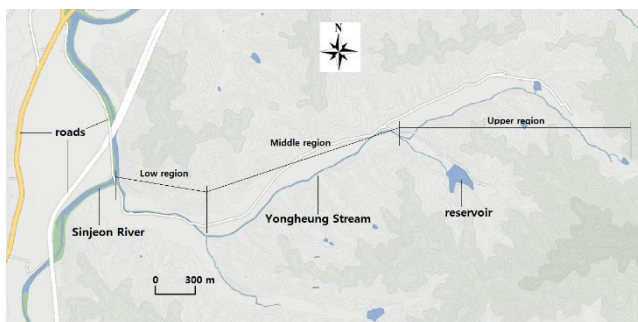


Fig. 2. Three internodes at the Yongheung Stream.

B. Floristic Analysis

The collected data are based on an extensive survey of the existing concern spatial distribution, habitat, as well as several life history traits of the alien plant. Sampling with quadrats (plots of a standard size) can be used for most plant communities [10]. Three sectors of the riparian vegetation on Yongheung Stream 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 growing life form. 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 [11]. Each species was collected, mounted, labeled, and systematically arranged in a herbarium. The

system of plant classification system was followed by Lee [12]. The identification of naturalized plants was followed by Korea National Arboretum [13]. Abundance and cover degree are usually estimated together in a single combined estimation or cover-abundance scale from Braun-Blanquet [14]. 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) [15]. The relative net contribution degree (r-NCD) was obtained by summing up the NCD values for those species belonging to particular taxa under consideration [16].

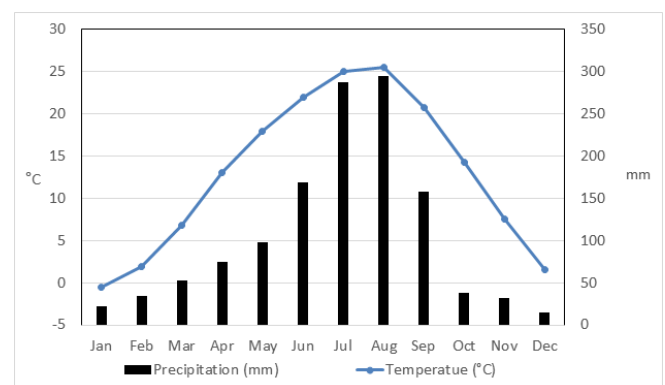


Fig. 3. Monthly mean of temperature and precipitation diagrams at Hapcheon-gun (1981-2020; Busan Regional Meteorological Administration, 2019).

C. Biotic Indices

Generally, abundance is used in its most simple form: plain occurrence = the taxon is or is not represented on the sample plot. Statistical treatment over a group of relevés then gives the, presence' = the percentage of relevés in which the species occurs [4]. Jaccard's Index of Similarity (ISj) was used to assess differences/similarities among the three sites as in (1) [17].

$$ISj = \{c/(a+b-c)\} \times 100 \quad (1)$$

where a is the number of species unique to region A, b is the number of species unique to region B, and c is the number of common species. For comparison, it was useful to apply another similarity test, The Sørensen index, also known as Sørensen's similarity coefficient, is a statistic used for comparing the similarity of two samples, as in (2). It also uses on presence-absence data. Sørensen's Index of Similarity (ISs), as in

$$\{2c/(2c+a+b)\} \times 100 \quad (2)$$

where c = the number of species common to the two sites, a = the total number of species at a given site and b = the total number of species at the other site in the comparison. Shannon-Weaver index of diversity (H') is the formula for calculating the Shannon diversity index [18], as in (3)

$$H' = - \sum p_i \ln p_i \quad (3)$$

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 Hill's diversity (N) [19] is the important value index of all the species) as in (4).

$$N = e^{H'} \quad (4)$$

The species richness was calculated by using the method, Margalef's index (R) of richness [20] as in (5).

$$R = (S-1) / \ln(n) \quad (5)$$

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 [19, 21] as in (6).

$$E = H' / \ln(S) \quad (6)$$

The percent of naturalized plant species (NI) and urbanization index (UI) were calculated the methods of Numata [22] and Yim and Jeon [23], respectively.

III. RESULTS

A. Regions

The mean stream width at this region is about 2.3 m. However, stream widths at this area are heavily variable due to reservoir. The application of the Braun-Blanquet approach for plant classification in this area is presented (Table I). According to the existing phytosociological data, 12 families, 34 genera, 35 species, 5 varieties have been identified. Naturalized plants were ten species. The dominant species (according to cover and frequency) that occur in the upper region are *Artemisia princeps* var. *orientalis*, *Equisetum arvense*, *Trifolium repens*, and *Bromus japonicas* which are over 4 for the application of the Braun-Blanquet approach. Dominant species in flood plains was *Zoysia japonica*. The total transformed Braun-Blanquet value and r-NCD at upper area were 95 and 1,055.6, respectively. The value of cover-abundance was total 14.87 (Table II). Cover-abundance values of trees and shrubs were 1.00 and 2.67, respectively. Cover-abundance values of grasses and forbs were 2.73 and 2.24, respectively. H' values were varied from 0.0 (trees) to 3.06 (forbs). For the community as a whole, richness of trees was very low (0.0). The total richness indices were varied from 0.96 (shrubs) to 5.96 (forbs). The evenness indices were varied from 0.89 (shrubs) to 1.00 (trees). Although evenness indices were different from each other, there were not shown significant differences ($p < 0.05$). When Jaccard's Index of Similarity (ISj) were applied to Yongheung Stream, the most similar sites were middle and low (ISj = 29.2%) (Table III). ISj value of the two riparian sites (upper and middle) which = 25.0%. Naturalized Index (NI) and Urbanization Index (UI) were 25.0% and 3.1%, respectively (Table IV).

B. Regions

The mean river width at the region is about 4.4 m. The vegetation of low water's edge was natural weeds, shrubs, and mixed. Riverbed area was dominated by the distribution of three willow species (*Populus euramericana*, *Salix*

gracilistyla, and *Salix koriyanagi*). The dominant species of left and right riparian areas was Compositae vegetation (*Artemisia princeps* var. *orientalis*) (Table I). The dominant vegetation of low water's edge was *Beckmannia syzigachne*. Land use in flood plains beyond river levee was dominated *Setaria viridis*. Other phyla were occasionally recorded in low densities. The survey region was a total of 59 taxa, including 17 families, 47 genera, 52 species, and 7 varieties. Naturalized plants were 15 species. The total transformed Braun-Blanquet value and r-NCD at middle area were 162 and 1,800.0, respectively.

The value of cover-abundance was total 10.64 (Table II). H' values were varied from 1.31 (trees) to 3.39 (forbs). The total richness indices were varied from 1.37 (trees) to 7.2 (forbs). The evenness indices were varied from 0.95 (trees) 0.99 (shrubs). Although evenness indices were different from each other, there were not shown significant differences ($p < 0.05$). NI and UI were 25.4% and 4.6%, respectively (Table IV).

C. Regions

The mean river width at the region was about 6.7 m. The dominant species of left and right riparian areas was Gramineae vegetation (twelve species including *Zoysia japonica*). The dominant vegetation of low water's edge was Polygonaceae (eight species including *Persicaria hydropoper*). The survey region was a total of 55 taxa, including 16 families, 43 genera, 47 species, and eight varieties (Table I). Naturalized plants were 20 species. The total transformed Braun-Blanquet value and r-NCD at middle area were 155 and 1,755.6, respectively.

The value of cover-abundance was total 10.07 (Table II). A Shannon-Weaver index (H') of diversity was different across growth forms, varying from 0.93 (shrubs) to 3.54 (forbs). The total richness indices were varied from 0.72 (shrubs) to 7.77 (forbs). The evenness indices were varied from 0.95 (grasses) 1.00. (trees and shrubs).

Upper and low were the most dissimilar (ISj = 16.8%). Sorensen's Index of Similarity was also used because it gives greater weight than Jaccard's to the species that recur in the two test areas than to those that are unique to either area. The ISs indices were varied from 28.7% (upper and low) to 45.2% (middle and low). The percent of naturalized plant species (NI) and urbanization index (UI) were 36.4% and 6.1%, respectively (Table IV).

TABLE I: LIST OF VASCULAR PLANTS, BRAUN-BLANQUET'S SCORE, AND R-NCD AT THREE REGIONS OF YONGHEUNG STREAM

Family	Species	Region			Invade d plant	r-NCD		
		Upper	Middle	Low		Upper	Middle	Low
Equisetaceae	<i>Equisetum arvense</i> L.	7	5	3		77.8	55.5	33.3
Salicaceae	<i>Populus euramericana</i> Guinier		1	1			11.1	11.1
	<i>Salix gracilistyla</i> Miq.		3	2			33.3	22.2
	<i>Salix koriyanagi</i> Kimura		2				22.2	
Araliaceae	<i>Acanthopanax elata</i> Seem.		2				22.2	
Moraceae	<i>Morus alba</i> L.	1	2			11.1	22.2	
Cannabinaceae	<i>Humulus japonicus</i> S. et Z.		3	2			33.3	22.2
Polygonaceae	<i>Persicaria hydropoper</i> (L.) Spach.	2	2	3		22.2	22.2	33.3
	<i>Persicaria sagittatum</i> L.	2	3	2		22.2	33.3	22.2
	<i>Persicaria orientalis</i> Spach	1	2			11.1	22.2	
	<i>Persicaria thunbergii</i> H. Gross		3	2			33.3	22.2
	<i>Rumex acetocella</i> L.		3	3	NAT		33.3	33.3
	<i>Rumex acetosa</i> L.		2	3			22.2	33.3
	<i>Rumex conglomeratus</i> Murr.			2	NAT			22.2
	<i>Rumex crispus</i> L.	2	3	3	NAT	22.2	33.3	33.3
	<i>Rumex nipponicus</i> Fr. et Sav.		2	3			22.2	33.3
Chenopodiaceae	<i>Chenopodium album</i> L.		2	5	NAT		22.2	55.6
	<i>Chenopodium album</i> var. <i>centrorubrum</i> Makino		3	4			33.3	44.4
Ranunculaceae	<i>Ranunculus chinensis</i> Bunge	2				22.2		
	<i>Ranunculus sceleratus</i> L.	2				22.2		
Brassicaceae	<i>Brassica vampestris</i> var. <i>nippo-oleifera</i> Makino		2	3			22.2	33.3
	<i>Capsella bursa-pastoris</i> (L.) Medicus		3	3			33.3	33.3
	<i>Cardamine flexuosa</i> With.		2	2			22.2	22.2
	<i>Cardamine leucantha</i> (Tausch) O.E. Schulz	2				22.2		
	<i>Lepidium apetalum</i> Willd.		2	2	NAT		22.2	22.2
	<i>Thlaspi arvense</i> L.		3	4	NAT		33.3	44.4
Caryophyllaceae	<i>Arenaria serpyllifolia</i> L.			1				11.1
Rosaceae	<i>Prunus serrulata</i> var. <i>spontanea</i> (Max.) Wils.	1	2	2		11.1	22.2	22.2
	<i>Rosa multiflora</i> Thunb.	3	3			33.3	33.3	
Leguminosae	<i>Amorpha fruticosa</i> L.		3		NAT		33.3	
	<i>Glycine soja</i> S. et Z.	2		2		22.2		22.2
	<i>Kummerowia striata</i> (Thunb.) Schindl.	2	2	3		22.2	22.2	33.3
	<i>Pueraria lobata</i> (Willd.) Ohwi	3	2			33.3	22.2	
	<i>Trifolium pratense</i> L.			1	NAT			11.1
	<i>Trifolium repens</i> L.	4	2	3	NAT	44.4	22.2	33.3
Oxalidaceae	<i>Vicia tetrasperma</i> (L.) Moench	3		3	NAT	33.3		33.3
	<i>Oxalis corniculata</i> L.	2	2	2		22.2	22.2	22.2
	<i>Oxalis stricta</i> L.	1	3	2		11.1	33.3	22.2
Onagraceae	<i>Oenothera odorata</i> Jacq.	1	2	4	NAT	11.1	22.2	44.4
Plantaginaceae	<i>Plantago asiatica</i> L.	3	2	2		33.3	22.2	22.2
	<i>Plantago lanceolata</i> L.	1		2	NAT	11.1		22.2
Euphorbiaceae	<i>Acalypha australis</i> L.	2	3	4		22.2	33.3	44.4
Compositae	<i>Ambrosia artemisiifolia</i> var. <i>elatior</i> Descourtils			2	NAT			22.2
	<i>Artemisia princeps</i> var. <i>orientalis</i> (Pampan.) Hara	9	7	5		100.0	77.8	55.6
	<i>Aster ciliatus</i> Kitamura	2	4	2		22.2	44.4	22.2
	<i>Bidens frondosa</i> L.		1	1	NAT		11.1	11.1
	<i>Cirsium japonicum</i> var. <i>ussuriense</i> Kitamura	2	3			22.2	33.3	
	<i>Cosmos bipinnatus</i> Cav.	2	1	4	NAT	22.2	11.1	44.4
	<i>Conyza canadensis</i> L.	1	3	4	NAT	11.1	33.3	44.4
	<i>Erigeron annuus</i> (L.) Pers.		4	3	NAT		44.4	33.3

	<i>Galingosa ciliate</i> Blake	2	2	NAT	22.2	22.2
	<i>Tagetes minuta</i> L.		2	NAT	22.2	22.2
	<i>Taraxacum officinale</i> Weber	2	3	NAT	22.2	33.3
	<i>Taraxacum mongolicum</i> H.Mazz.	3	2		33.3	22.2
Gramineae	<i>Agropyron tsukusinense</i> (Honda) Ohwi	3	2		33.3	22.2
	<i>Alopecurus aequalis</i> var. <i>amurensis</i> Ohwi.	1	2		11.1	22.2
	<i>Avena fatua</i> L.	2	2	NAT	22.2	22.2
	<i>Beckmannia syzigachne</i> (Steud.) Fern.	3	5		33.3	55.6
	<i>Bromus japonicus</i> Thunb.	4	4		44.4	44.4
	<i>Digitaria sanguinalis</i> (L.) Scop.	3	4		33.3	44.4
	<i>Echinochloa crus-galli</i> (L.) Beauv.		3		33.3	33.3
	<i>Miscanthus sacchariflorus</i> Benth.		2		22.2	33.3
	<i>Miscanthus sinensis</i> var. <i>purpurascens</i> Rendle	1	3		11.1	33.3
	<i>Phalaris arundinacea</i> L.		2		22.2	
	<i>Phragmites japonica</i> Steud.		2		22.2	
	<i>Poa sphondylodes</i> Trin.	1	3		11.1	33.3
	<i>Setaria viridis</i> (L.) Beauv.	2	6		22.2	66.7
	<i>Zoysia japonica</i> Steud.	3	4		33.3	44.4
Cyperaceae	<i>Carex dimorpholepis</i> Steud.		5		55.6	33.3
	<i>Carex neurocarpa</i> Maxim.		2		22.2	
	Total	40	59	56	1055.6	1800.0
1755.6						

NAT: Naturalized plants.

TABLE II: MEAN COVER-ABUNDANCE OF SPECIES AND DIVERSITY INDICES AT YONGHEUNG STREAM

Growth form	No. species (%)	Mean cover-abundance of species	Diversity (H')	Diversity (N)	Richness	Evenness
A region						
Trees	1 (2.5)	1.00	0.0	1.00	0.00	1.00
Shrubs	3 (7.5)	2.67	0.97	2.65	0.96	0.89
Grasses	11 (27.5)	2.73	2.23	9.30	2.94	0.93
Forbs	25 (62.5)	2.24	3.06	21.44	5.96	0.95
Total	40 (100.0)	8.63	-	-	-	-
B region						
Trees	4 (6.8)	2.25	1.31	3.71	1.37	0.95
Shrubs	6 (10.2)	2.50	1.77	5.88	1.85	0.99
Grasses	17 (28.8)	3.29	2.76	15.73	3.97	0.97
Forbs	32 (54.2)	2.59	3.39	25.79	7.02	0.98
Total	59 (100)	10.64	-	-	-	-
C region						
Trees	3 (5.4)	2.00	1.10	3.00	1.12	1.00
Shrubs	2 (3.5)	2.00	0.93	2.00	0.72	1.00
Grasses	14 (25.0)	3.29	2.49	12.11	3.40	0.95
Forbs	37 (66.1)	2.78	3.54	34.56	7.77	0.98
Total	56 (100)	10.07	-	-	-	-

A: Upper area, B: Middle area, C: low area.

TABLE III: INDEX OF SIMILARITY VALUES COMPARING THE THREE STUDY REGIONS

Region	Jaccard's (ISj)	Sorensen's (ISs)
A and B	25.0	40.0
A and C	16.8	28.7
B and C	29.2	45.2

A, B, and C are the same as Table 2.

TABLE IV: NATURALIZED INDEX (NI) AND URBANIZATION INDEX (UI) IN THE THREE REGIONS

Index	Region			Total
	Upper	Middle	Low	
NI(%)	25.0	25.4	36.4	29.6
UI(%)	3.1	4.6	6.1	6.4

IV. DISCUSSION

Waterway, channel and waterfront property owners with well-vegetated riparian zones enjoy some of the most biologically diverse and scenic communities in the Yongheung Stream. Native vegetation that occurs along channel provides an attractive landscape with many important benefits, and helps preserve plants and animals that make our area unique. Native plants have evolved under local conditions. An invasive-exotic plant species is an introduced species that has been shown to displace the native vegetation by out-competing native species. Naturalized plants are small in the upper region, but more

and more naturalized plants descend to the middle and downstream (Table 1). Native plants in Korea is 4,412 taxa on 2019. A total of 326 taxa of 184 genera of 39 families were identified and analyzed for their distributional origin and habitat characteristics in Korea on 2017 [24]. Korean plant species include 4726 species including 326 naturalized plants.

Naturalized Index (NI) and Urbanization Index (UI) were 29.6% and 6.4%, respectively (Table 4). This result indicated that NI of the study area was higher than the Korean average of NI (6.9%). The increase in naturalized plants indicates that ecosystem disturbances are known in this area (Yongheung Stream). Invasion of natural ecosystems by exotic plant species is recognized as a major threat to biodiversity [25]. Species and plants in Genus *Rumex* (*Rumex acetocella*, *Rumex conglomeratus*, and *Rumex crispus*) are rapidly spreading in Korea, causing damage to ecosystems and becoming social problems [26, 27]. Most species originated from Europe and North America. Young people have taken over rural areas and the remaining rural population has been neglected due to the old aging process and has won no victory over native plants.

Conservation science is concerned with understanding why distribution and abundance patterns of species vary in time and space [28]. The impacts of human activities on biodiversity are projected to have broad global ramifications, but the spatial extent of those impacts will be uneven [29]. Demonstrating the potential consequences for failing to consider ecosystem dynamics in conservation designs is important, but the planning tools to incorporate such effects analytically are still in their infancy [28].

The loss of biological diversity is a serious ecological problem and a central component in current strategies for managing environmental change. Global biodiversity is declining at an accelerated rate [3]. This is both a biological and social concern: it may lead to dysfunctions at genetic, species or ecosystem levels, and lost species or habitats may have important commodity and/or socio-cultural values. Human action, particularly land uses that alter habitat, is a key cause of biodiversity loss. Human neglect and indifference can also cause loss of biological diversity to dominate any naturalized plant. Research is needed to understand and manage biodiversity loss.

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