# FLORISTIC ANALYSIS OF RIPARIAN ZONES AT THE ANGEUM RIVER, HAPCHEON-GUN, KOREA

**Man-Kyu, Huh**
Dong-eui University
**SOUTH KOREA**
mkhuh@deu.ac.kr

## ABSTRACT

Riparian zones are an interface between terrestrial and aquatic ecosystems and play a critical role in supporting biota and biodiversity. This study was carried out on the Angeum River in Korea. A quadrat delimits an area in which vegetation cover can be estimated, plants counted, or species listed. According to the existing phytosociological data, the survey area was a total of 76 taxa, including 20 families, 55 genera. Naturalized plants were 24 species. The dominant species (according to cover and frequency) that occur in the upper area of this river are *Setaria viridis* and *Zoysia japonica.* The dominant species of left and right riparian areas at middle area was Gramineae vegetation (*Zoysia japonica*). The dominant vegetation of low water's edge at low area was *Brassica vampestris* var. *nippo-oleifera.* Braun-Blanquet value at upper, middle, and low areas were 112, 126, and 172, respectively. The relative net contribution degree (r-NCD) at upper, middle, and low areas were 2,155.6, 3,077.8, respectively. The total transformed Braun-Blanquet value and r-NCD at middle area were 172 and 2,700.0, and 2,700.0, respectively. This study was described as attempts to address by using a sample field data for assessment and prediction of the ecological effects of natural or human-caused changes in the rural small river.

**Keywords:** Angeum River, Braun-Blanquet, biota, riparian zones.

## INTRODUCTION

Rivers have been the focus of human activity since the early civilizations. Even in modern times a large number of activities of the engineers such as water supply, irrigation, water quality control, power generation, flood control, river regulation, navigation and recreation are centered around rivers (Garde, 2006).

It would be convenient if the component activities of agriculture could be simply and quantitatively related to their impacts on freshwater systems (Moss, 2008). This would be an ideal basis for creating legislation, for designing incentive schemes to optimize agricultural practice and for minimizing environmental consequences. However, it is far from possible. Both agricultural and freshwater systems are complex and the relationships between them make a mesh of many dimensions.

Riparian zones are open systems, dynamically linked longitudinally, laterally and vertically by hydrological and geomorphic process and vegetation succession (Gregory et al., 1991). Riparian areas occur along many types of waterways, including streams, meadows, flood plains, marshes, springs, and lake shores. They composed of land and water forming a transition from aquatic to terrestrial ecosystems. One of the most perplexing issues in river ecology involves the definition and delineation of riparian zones and their associated vegetation (Verry et al., 2004). A remarkable number of recent scientific studies have proven the outstanding importance of riparian vegetation for maintaining a rich and distinctive biodiversity (Poiani et al., 2000; Arizpe et al., 2008). Habitat diversity within riparian and flood plain environments is related to the regular and repeated rejuvenation of successions associated with disturbance (Petts, 1990). I assume that the primary question underlying monitoring is to ask whether biodiversity is changing over time and collecting sites of a river.

The aim of this study is to present a total riparian floristic survey of the Angeum River in a typical, small-sized, southern Korean rural area. Objectives were to analyze and describe the biological indices including species diversity, richness, and evenness.

## METHODOLOGY

### Surveyed areas

Riparian habitats and stream side zones should be managed on a highly individualistic basis, taking into account terrain, soils, plant communities. This study was carried out on the Angeum River (the starting point of upper area: 35°29′245″N/128°11′924″E, the terminal of low area: 35°30′351″N/128°10′330″E), located at Hapcheon-gun, Gyeongsangnam-do province in Korea (Fig. 1). The river is approximately 3.8 kilometers in length with a varying width of between 1.5 and 16.2 meters. Lowlands are usually no higher than 110 m (360 ft), while uplands are somewhere around 310 m (1,170 ft) to 380 m (1,247 ft).

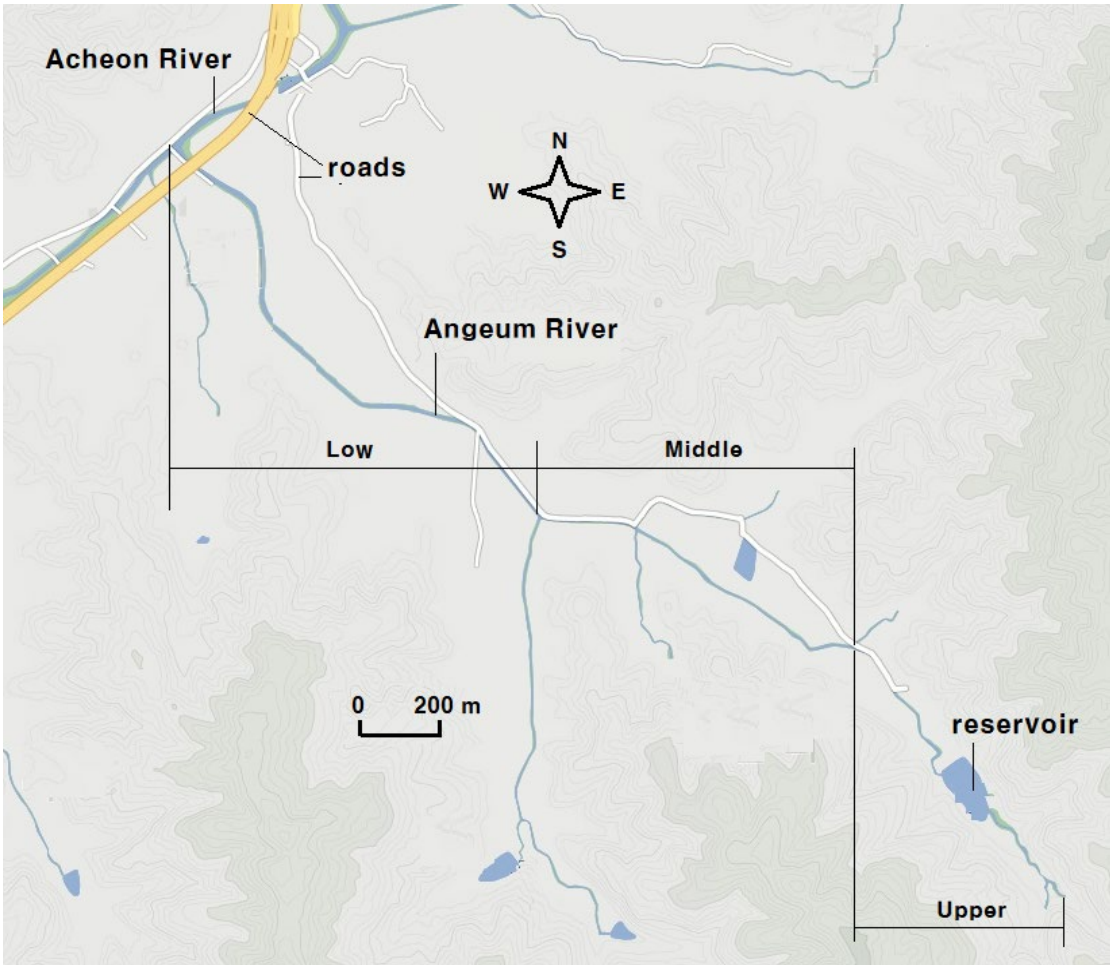


**Figure 1:** Location of the study area and the three detailed internodes at the Angeum River.

**Floristic analysis**

Data recorded on various parameters were subjected to phytosociological analysis. The simplest floristic analysis is a list of names of plants occurring in a sample quadrat of a certain size in a homogeneous representative part of the vegetation to be described.

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 Angeum 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 (Moon and Huh, 2016). Each species was collected, mounted, labeled, and systematically arranged in a herbarium. The system of plant classification system was followed by Lee (2007). The identifications of 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). Two scales are used. One consists of a plus sign and a series of numbers from 1 to 5 denoting both the numbers of species and the proportion of the area covered by that species, ranging from + (sparse and covering a small area) to 5 (covering more than 75% of the area). The second scale indicates how the species are grouped and ranges from Soc. 1 (growing singly) to Soc. 5 (growing in pure populations). 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).

**Biotic Indices**

Various indices of diversity were calculated using Shannon-Wiener diversity index (H') (Shannon and Weaer, 1963), Simpson's index of diversity (N) (Simpson, 1949), Simpson's index of dominance (Simpson, 1949), Margalef Richness index (Magurran, 1988), Evenness index (Hill, 1973; Pielou, 1966).

Jaccard's Index of Similarity (JIS) was used to assess differences/similarities among the three sites. JIS = c/(a + b + c) × 100, where "c" is the number of common species, "a" is the number of species unique to site #1, and "b" is the number of species unique to site #2. For comparison, it was useful to apply another similarity test, Sorensen's Index of Similarity (SIS), SIS = 2c/(a + b + C) × 100, a 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.

**RESULTS and DISCUSSION**

**Upper area**

The mean river width at this area is about 1.5 m. The small rural stream with a riparian zone dominated by grasslands (grasses and herbs), with a narrow strip of trees and shrubs along the stream. At total area, the application of the Braun-Blanquet approach for plant classification in this area is presented in the article. The river width was relative large and the depth of water was swallow and distributions of aquatic plants developed very well in riparian.

According to the existing phytosociological data, the survey area was a total of 47 taxa, including 14 families, 39 genera, 41 species, and six varieties (Table 1). Naturalized plants were seven species.

The dominant species (according to cover and frequency) that occur in the A area are *Setaria viridis* and *Zoysia japonica* (Table 2). The dominant vegetation of low water's edge was *Persicaria longiseta.* Dominant species in flood plains was *Humulus japonicus.* Other phyla were occasionally recorded in low densities. This land was used as farmland and crops were being grown. The total transformed Braun-Blanquet value and r-NCD at upper area were 112 and 2,155.6, respectively.

The value of cover-abundance was total 10.1 (Table 3). Cover-abundance values of trees and shrubs were 2.0 and 2.4, respectively. Cover-abundance values of grasses and forbs were 3.3 and 2.4, respectively. A Shannon-Weaver indices (H′) of diversity were varied from 0.0 (trees) to 3.07 (forbs). For the community as a whole, richness of trees was very low (0.0). The total richness indices were varied from 1.61 (shrub) to 6.97 (forbs). The evenness indices were varied from 0.89 (forbs) to 0.98 (shrub) except trees. Although evenness indices were different from each other, there were not shown significant differences ($p < 0.05$). Naturalized index (NI) was varied from 13.0% (upper area) to 35.0% (low area) (Table 4). The urbanization index (UI) was varied from 1.8 (upper area) to 6.4 (low area). I calculated the pairwise similarity between all the presence in each species (Table 5). Areas A and C had the most similar plant species composition.

**Middle area**
The mean river width at the area is about 5.6 m. The survey area was a total of 61 taxa, including 16 families, 44 genera, 57 species, and four varieties. Naturalized plants were 16 species (Table 1). Riverbed area was dominated by the distribution of the willow (*Salix gracilistyla*). The vegetation of low water's edge was natural weeds, shrubs, and mixed. The dominant species of left and right riparian areas was Gramineae vegetation (*Zoysia japonica*) (Table 2). The dominant vegetation of low water's edge was *Persicaria hydropoper* and use in flood plains beyond river levee was dominated *Equisetum arvense*.

The total transformed Braun-Blanquet value and r-NCD at middle area were 126 and 3,077.8, respectively. The value of cover-abundance was total 11.5 (Table 3). A Shannon-Weaver indices (H′) of diversity were varied from 0.0 (trees) to 3.6 (forbs). The total richness indices were varied from 1.89 (shrub) to 8.4 (forbs) except trees. The evenness indices were varied from 0.95 (grasses) 0.98 (forbs). Although evenness indices were different from each other, there were not shown significant differences ($p < 0.05$).

**Low area**
The mean river width at the area was about 16.2 m. Riverbed area was dominated by the distribution of the willow (three *Salix* species). The survey area was a total of 54 taxa, including 17 families, 38 genera, 49 species, and five varieties (Table 2). Naturalized plants were 21 species. The dominant species (according to cover and frequency) that occur in the A area are *Setaria viridis* and *Zoysia japonica.* The dominant vegetation of low water's edge was *Brassica vampestris* var. *nippo-oleifera.* The total transformed Braun-Blanquet value and r-NCD at low

area were 172 and 2,700.0, respectively.

The value of cover-abundance was total 8.98 (Table 3). A Shannon-Weaver index (H′) of diversity was different across growth forms, varying from 0.69 (shrubs) to 3.73 (forbs) except trees (0.0). The total richness indices were varied from 1.24 (shrubs) to 7.87 (forbs) except trees. The evenness indices were varied from 0.63 (shrubs) 1.03 (forbs) except trees.

The spatial heterogeneity of environmental resources results in the variance seen in the spatial distribution of vegetation. Understanding the relationships between spatial and temporal environmental variation remains a fundamental challenge in ecology (Crone, 2016). Working with these assumptions, Moyle et al (1996) present three basic approaches to riparian management, recognizing that these approaches are highly generalized: (1) the low protection approach, (2) the moderate protection approach, and (3) the high protection approach. I recognize that under almost any circumstances, riparian management for the entire the Angeum River, or even for one watershed, is likely to be low protection approach among the three approaches. Under this approach, the highest value of stream side areas is for direct use: housing, road constructions, transportation corridors, grazing, and other factors.

**Table 1: Information** of vascular riparian plants, Braun-Blanquet value, and r-NCD at three areas of the Angeum River

| | Area | | | Total |
|---|---|---|---|---|
| | Upper | Middle | Low | |
| No. of family | 14 | 16 | 17 | 20 |
| No. of genus | 39 | 44 | 38 | 55 |
| No. of species | 47 | 61 | 54 | 76 |
| No. of individuals per plot | 36 | 30 | 41 | 107 |
| No. of NAT | 7 | 16 | 21 | 24 |
| Braun-Blanquet value | 112 | 126 | 172 | 637 |
| r-NCD | 2,155.6 | 3,077.8 | 2,700.0 | 7,933.3 |

NAT: Naturalized plants.

**Table** 2: List of vascular plants, Braun-Blanquet's score, and r-NCD at three areas of the Angeum Riv**er**

| Family | Species | Area | | | Invaded plant | r-NCD | | |
|---|---|---|---|---|---|---|---|---|
| | | Upper | Middle | Low | | Upper | Middle | Low |
| Equisetaceae | *Equisetum arvense* L. | 3 | 5 | 3 | | 33.3 | 55.6 | 33.3 |
| Salicaceae | *Salix fragilis*L. | | 3 | 2 | | | 33.3 | 22.2 |
| | *Salix gracilistyla* Miq. | | 2 | 1 | | | 22.2 | 11.1 |
| | *Salix koriyanagi* Kimura | 2 | 1 | 2 | | 22.2 | 11.1 | 22.2 |
| Cannabinaceae | *Humulus japonicus* S. et Z. | 4 | 1 | | | 44.4 | 11.1 | |
| Urticaceae | *Boehmeria longispica* Steud. | 3 | 2 | | | 33.3 | 22.2 | |
| | *Boehmeria spicata* (Thunb.) Thunb. | 2 | 3 | | | 22.2 | 33.3 | |
| Polygonaceae | *Persicaria hydropoper* (L.) Spach. | 3 | 5 | 2 | | 33.3 | 55.6 | 22.2 |
| | *Persicaria longiseta* (De Bruyn) Kitagawa | 4 | 4 | 2 | | 33.3 | 44.4 | 22.2 |
| | *Persicaria nodosa* (Persoon) Opiz | 2 | 2 | | | 22.2 | 22.2 | |
| | *Persicaria orientalis* Spach | | | 3 | | | | 33.3 |
| | *Persicaria thunbergii* H. Gross | | 3 | | | | 33.3 | |
| | *Reynoutria japonica* Houtt | 2 | | | | 22.2 | | |
| | *Rumex acetocella* L. | | 3 | 3 | NAT | | 33.3 | 33.3 |
| | *Rumex acetosa* L. | 2 | 3 | 3 | | 22.2 | 33.3 | 33.3 |
| | *Rumex conglomeratus* Murr. | 3 | 4 | 5 | NAT | 33.3 | 44.4 | 55.6 |
| | *Rumex crispus* L. | | 2 | 2 | NAT | | 22.2 | 22.2 |
| | *Rumex nipponicus* Fr. et Sav. | 2 | | | | 22.2 | | |
| Chenopodiaceae | *Chenopodium acuminatum* Willd. | 1 | 2 | 3 | | 11.1 | 22.2 | 33.3 |
| | *Chenopodium album* L. | 1 | 1 | 1 | NAT | 11.1 | 11.1 | 11.1 |
| | *Chenopodium album* var. *centrorubrum* Makino | 2 | 4 | 4 | | 22.2 | 44.4 | 44.4 |
| Amaranthaceae | *Achyranthes japonica* (Miq.) Pa. | 2 | 2 | | | 22.2 | 22.2 | |
| | *Amaranthus lividus* L. | | 2 | 3 | NAT | | 22.2 | 33.3 |
| Phytolaccaceae | *Phytolacca americana* L. | | | 2 | NAT | | | 22.2 |
| Brassicaceae | *Brassica juncea* Czern | 2 | 1 | | | 22.2 | 11.1 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | *Brassica vampestris* var. *nippo-oleifera* Makino | 3 | 4 | 5 | | 33.3 | 44.4 | 55.6 |
| | *Capsella bursa-pastoris* (L.) Medicus | 2 | 2 | 2 | | 22.2 | 22.2 | 22.2 |
| | *Lepidium apetalum* Willd. | | 2 | 3 | NAT | | 22.2 | 33.3 |
| | *Lepidium virginicum* L. | | | 2 | NAT | | | 22.2 |
| | *Thlaspi arvense* L. | | 2 | 2 | NAT | | 22.2 | 22.2 |
| Caryophyllaceae | *Arenaria serpyllifolia* L. | | 3 | 3 | | | 33.3 | 33.3 |
| | *Stellaria aquatica* (L.) Scop. | | 2 | 3 | | | 22.2 | 33.3 |
| Rosaceae | *Duchesnea chrysantha* (Zoll. Et Morr) Miq. | 2 | | | | 22.2 | | |
| | *Potentilla fragarioides* var. *major* Max. | 3 | | | | 33.3 | | |
| | *Prunus jamasakura* Sieb. | 2 | 3 | 1 | | 22.2 | 33.3 | 11.1 |
| | *Rosa multiflora* Thunb. | 2 | 3 | | | 22.2 | 33.3 | |
| Leguminosae | *Glycine soja* Sieb. et Zucc. | 4 | | | | 44.4 | | |
| | *Kummerowia striata* (Thunb.) Schindl. | 2 | | | | 22.2 | | |
| | *Pueraria lobata* (Willd.) Ohwi | 3 | 3 | | | 33.3 | 33.3 | |
| | *Trifolium repens* L. | 3 | 4 | 3 | NAT | 33.3 | 44.4 | 33.3 |
| | *Vicia tetrasperma* (L.) Moench | | 2 | | NAT | | 22.2 | |
| Oxalidaceae | *Oxalis corniculata* L. | | 2 | 2 | | | 22.2 | 22.2 |
| | *Oxalis stricta* L. | | | 2 | | | | 22.2 |
| Violaceae | *Viola patrinii* DC. | 1 | | | | 11.1 | | |
| Onagraceae | *Oenothera odorata* Jacq. | | 2 | 2 | NAT | | 22.2 | 22.2 |
| Umbelliferae | *Oenanthe javanica* (Bl.) DC. | | | 2 | | | | 22.2 |
| Plantaginaceae | *Plantago asiatica* L. | 3 | 4 | 4 | | 33.3 | 44.4 | 44.4 |
| | *Plantago laceolata* L. | | 2 | 3 | NAT | | 22.2 | 33.3 |
| Compositae | *Ambrosia artemisiifolia* var. *elatior* Descourtils | | | 2 | NAT | | | 22.2 |
| | *Artemisia princeps* Pampan. | 5 | 7 | 8 | | 55.6 | 77.8 | 88.9 |
| | *Artemisia selengensis* Turcz. | | 2 | 3 | | | 22.2 | 33.3 |
| | *Bidens bipinnata* L. | 3 | 2 | | | 33.3 | 22.2 | |
| | *Bidens frondosa* L. | | | 2 | NAT | | | 22.2 |
| | *Cirsium japonicum* var. *ussuriense* Kitamura | 1 | 2 | | | 11.1 | 22.2 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | *Cosmos bipinnatus* Cav. | | 2 | 2 | NAT | | 22.2 | 22.2 |
| | *Conyza canadensis* L. | 3 | 4 | 3 | NAT | 33.3 | 44.4 | 33.3 |
| | *Erechtites hieracifolia* Raf. | | | 2 | NAT | | | 22.2 |
| | *Erigeron annuas* (L.) Pers. | | 3 | 3 | NAT | | 33.3 | 33.3 |
| | *Galingosa ciliate* Blake | | 2 | 2 | NAT | | 22.2 | 22.2 |
| | *Petasites japonicus* (Sieb. et Zucc.) Maxim. | 2 | 2 | 2 | | 22.2 | 22.2 | 22.2 |
| | *Tagetes minuta* L. | 2 | 3 | | | 22.2 | 33.3 | |
| | *Taraxacum officinale* Weber | 1 | 3 | 4 | NAT | 11.1 | 33.3 | 44.4 |
| | *Xanthium strumarium* L. | 2 | 2 | 2 | NAT | 22.2 | 22.2 | 22.2 |
| Gramineae | *Agropyron tsukusinense* (Honda) Ohwi | 2 | 3 | 3 | | 22.2 | 33.3 | 33.3 |
| | *Alopecurus aequalis* var. *amurensis* Ohwi. | 3 | 2 | 2 | | 33.3 | 22.2 | 22.2 |
| | *Beckmannia syzigachne* (Steud.) Fern. | | 4 | 3 | | | 44.4 | 33.3 |
| | *Digitaria sanguinalis* (L.) Scop. | 5 | 4 | 2 | | 55.6 | 44.4 | 22.2 |
| | *Echinochloa crus-galli* (L.) Beauv. | 2 | 4 | 4 | | 22.2 | 44.4 | 44.4 |
| | *Miscanthus sacchariflorus* Benth. | | 3 | 3 | | | 33.3 | 33.3 |
| | *Miscanthus sinensis* var. *purpurascens* Rendle | 2 | 3 | 3 | | 22.2 | 33.3 | 33.3 |
| | *Phragmites japonica* Steud. | 2 | 3 | 2 | | 22.2 | 33.3 | 22.2 |
| | *Poa sphondylodes* Trin. | 2 | 2 | | | 22.2 | 22.2 | |
| | *Setaria viridis* (L.) Beauv. | 6 | 5 | 6 | | 66.7 | 55.6 | 66.7 |
| | *Zoysia japonica* Steud. | 6 | 9 | 9 | | 66.7 | 100.0 | 100.0 |
| Cyperaceae | *Carex dimorpholepis* Steud. | | 2 | | | | 22.2 | |
| | *Carex neurocarpa* Maxim. | | 1 | 1 | | | 11.1 | 11.1 |

NAT: Naturalized plants.

**Table 3.** Mean cover-abundance of species and diversity indices at the Angeum River

| Growth form | No. species (%) | Mean cover-abundance of species | Diversity (H`) | Diversity (N) | Richness | Evenness |
|---|---|---|---|---|---|---|
| Upper | | | | | | |
| Trees | 1 (2.1) | 2.00 | 0.00 | 1.00 | 0.71 | 0.00 |
| Shrubs | 5 (10.6) | 2.40 | 1.59 | 4.90 | 1.44 | 0.99 |
| Grasses | 10 (21.3) | 3.30 | 2.19 | 8.95 | 1.74 | 0.95 |
| Forbs | 31 (66.0) | 2.39 | 3.07 | 21.56 | 3.61 | 0.89 |
| Total | 47 (100.0) | 10.09 | - | - | - | - |
| Middle | | | | | | |
| Trees | 1 (1.9) | 3.00 | 0.00 | 1.00 | 0.58 | 0.00 |
| Shrubs | 6 (9.8) | 2.33 | 1.74 | 5.67 | 1.62 | 0.97 |
| Grasses | 14 (23.0) | 3.50 | 2.52 | 12.40 | 2.01 | 0.95 |
| Forbs | 40 (65.6) | 2.68 | 3.60 | 36.67 | 3.87 | 0.98 |
| Total | 61 (100) | 11.51 | - | - | - | - |
| Low | | | | | | |
| Trees | 1 (1.9) | 1.00 | 0.00 | 1.00 | 1.00 | 0.00 |
| Shrubs | 3 (5.6) | 1.67 | 0.69 | 1.96 | 1.34 | 0.63 |
| Grasses | 12 (22.2) | 3.42 | 2.33 | 10.28 | 1.87 | 0.94 |
| Forbs | 38 (70.4) | 2.89 | 3.73 | 41.62 | 3.62 | 1.03 |
| Total | 54 (100) | 8.98 | - | - | - | - |

**Table 4:** Naturalized index (NI) and urbanization index (UI) in the three study areas

| Index | area | | | Total |
|---|---|---|---|---|
| | Upper | Middle | Low | |
| NI(%) | 13.0 | 25.8 | 35.0 | 31.9 |
| Ul(%) | 1.8 | 5.2 | 6.4 | 6.8 |

**Table 5:** Index of similarity values comparing the three study areas

| Area | Jaccard's (JIS | Sorensen's (SIS) |
|---|---|---|
| Upper and Middle | 22.8 | 37.1 |
| Upper and Low | 27.2 | 42.7 |
| Middle and Low | 15.3 | 26.5 |

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

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