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Characteristics of species richness and diversity of woody vegetation in the natural rivers in Korea and its meaning to restoration design in flood plains[1]

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ABSTRACT

In order to get basic data for flood plain restoration, we surveyed the woody vegetation in Korean natural rivers and analyzed the species' characteristics with regards to patterns of richness and diversity. These characteristics were higher in hard wood forests than those in soft wood forests, such as *Salix* spp. community. Futhermore, they were the highest in the *Prunus sargentii-Pinus densiflora* community(H' 1.095), and the lowest in the *Carpinus laxiflora* community(H' 0.118) among the hard wood forests. Species' richness diversity were the highest in the *Salix gracilistyla* community, but the lowest in the *S. koriyangi* community or *S. koreensis* community among the soft wood forests.

With regards to the dominant index, just one community is over 0.9, 13 communities are between 0.3-0.7 and 15 communities are less than 0.3. The *Salix koreensis* community was the highest at 0.931, and *Prunus sargentii-Pinus densiflora* community was the lowest at 0.13.

Species' richness and diversity was significantly correlated with tree layer coverages and degree of slope. These results mean that in order to increase plant species diversity in flood plains planted hard woody trees, such as oaks and fir, are needed to suit environmental conditions with steeper slope and lower canopy coverage.

KEY WORDS: SPECIES DIVERSITY INDEX, HARD WOOD FOREST, SOFT WOOD FOREST, SLOPE DEGREE

INTRODUCTION

In Korea, natural rivers hardly exist and there is no basic research on which tree to plant for restoration of the river area(Park, 2001). Several kinds of river restoration projects are on going throughout Korea, but due to lack of information for natural rivers, especially regarding woody plants in flood plains, those projects will experience many problems. Ecological communities do not contain an equal number of species, and one of the currently active areas of research in community ecology is the study of species' richness or biodiversity. In 1876, Wallace recognized that animal life was more abundant and varied in the tropics than in other parts of the globe, and the same applied to plants. Different patterns of variation have long been known on islands; it has been shown that small or remote islands have fewer species than large islands or those nearer to continents(MacArthur and Wilson, 1967). The regularity of these patterns for many taxonomic groups suggests that they have been produced in conformity with

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a set of basic principles rather than as accidents of history.

Biodiversity measurement is an important part of conservation biology, because we need an inventory of what is to be protected. Whereas conservation biologists often concern themselves with particular species, community ecologists tend to lump the species together and condense information into counts of species. Often this is done within specific area. This community-based approach looks for large patterns in groups of species and tries to understand what has caused them.

This study surveyed the woody plant communities in natural rivers by measuring species richness, diversity and dominance along with analyzing, the species diversity with environmental factors. This research will give a basic methodology to construct a high diversity plant community in river restoration.

MATERIALS AND METHODS

1. Survey site

A field survey was carried out in 10 semi-natural rivers around the Nakdong River Basin from August to October 2008(Figure 1). Aerial photographs of the river were first reviewed in the lab. We choose a natural river where there was no artificial disturbance, such as land management or residential scarring. The upper part of the Nakdong River was selected based on these factors.

The river's climate condition(Heinrich, 1975) is a temperate deciduous forest ecosystems(Figure 2-4).

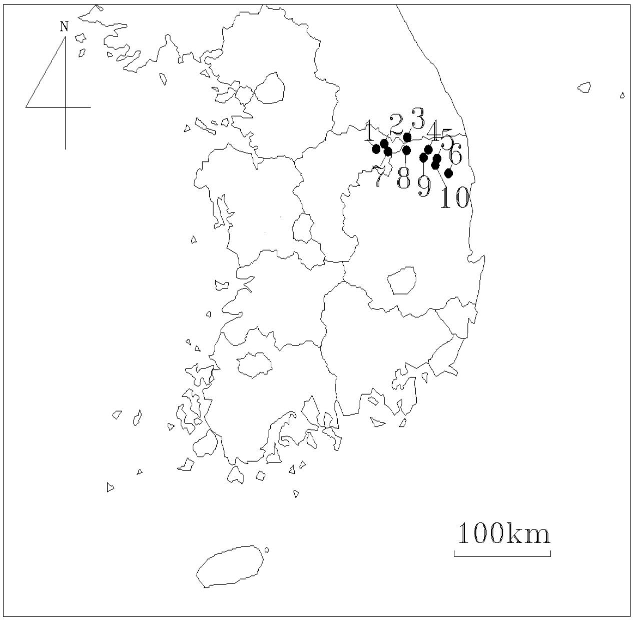

Figure 1. Map of study site in Korea. (1, Maepo stream; 2, Sajiwon stream; 3, Okdong stream; 4, Byeongoh stream; 5, Golpo stream; 6, Sinam stream; 7, Nam stream; 8, Songjeongri stream; 9, Hyeondong stream; 10, Hoeryong stream)

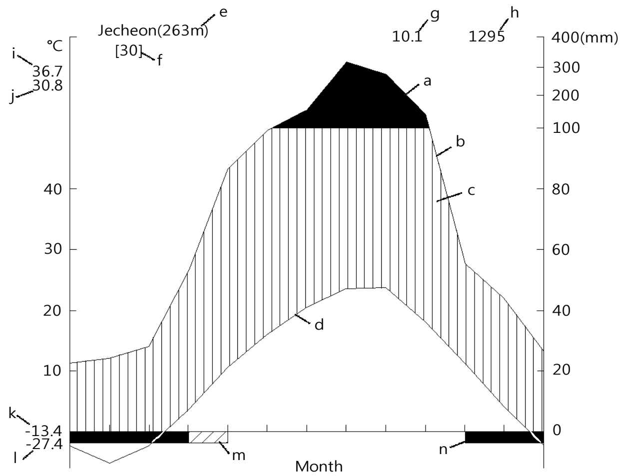

Figure 2. The climate-diagram of Jecheon for 30 years from 1971 to 2000

a=mean monthly rain > 100 ㎜ (black scale reduced to 1/10), b=curve of mean monthly precipitation, c=relative humid season (vertical shading), d=curve of mean monthly temperature, e=station and height above sea level, f=duration of observations in years, g=mean annual

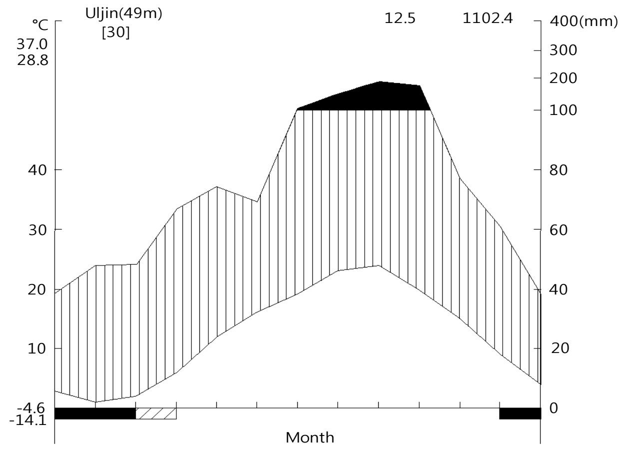

Figure 3. The climate-diagram of Uljin for 30 years from 1971 to 2000

temperature in ℃, h=mean annual precipitation in mm, i=highest temperature recorded, j=mean daily maximum of the warmest month, k=mean daily minimum of the coldest month, l=lowest temperature recorded, m=months with absolute minimum below 0 ℃ (diagonal shading)=late or early frost occur, n=months with mean daily minimum below 0 ℃ (black)=cold season.

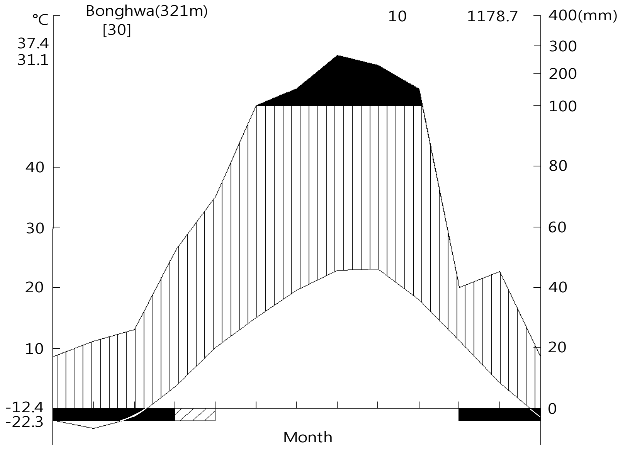

Figure 4. The climate-diagram of Bonghwa for 30 years from 1971 to 2000

2 Measurement of species diversity and dominance

Species richness was based on the number of species and their diversity(H') as determined by a flows calculation(Shannon-Wiener, 1949).

Diversity index(H') = $-\Sigma$(pi log pi)
(pi=ni/N; ni, species ith proportion, N, all species total value)

Dominance index(C) was calculated as flows(Simpson, 1949).

Dominance index(C)= Σ(In/N)2
In= each species proportion value
N= all species total value

RESULTS AND DISCUSSION

The Shannon-Wiener diversity index and the Simpson dominance index was determined in each community group in order to understand indirect quality including the maturity and stability of the community(Table 1). The species diversity and dominance index had a negative correlation with the dominance value.

The species diversity and maturity of the community are in direct proportion (Loucks, 1970) and the species diversity increased with heterogeneous or a complicated living environment as well as the localized disturbances (Krebs, 1985; Barbour *et al*., 1987).

In regards to the Whittaker & Levin(1977) and Menge (1979), the most important influence is spatial heterogeneity, in which the species diversity is maintained in the community.

According to Whittaker(1965), dominant species is a species with a dominance index over 0.9, 2-3 species at 0.3-0.7 or several species at less than 0.3.

In this research area, the community with highest species diversity index was the *Prunus sargentii* and *Pinus densiflora* community, which was 1.10. The oher species over 1 were *Fraxinus sieboldiana*, *Quercus mongolica*, *Pueraria thunbergiana*, *Euonymus alatus* for. *ciliato dentata*, *Rhus verniciflua*, *Lathyrus vaniotii*, *Carex lanceolata*, *Potentilla freyniana*, *Corylus heterophylla* and *Lespedeza maximowiczii*. The high species diversity is due to relatively uniform distribution of various species.

Note; H'=Shannon-Wiener diversity index, C=Simpson dominance index

The species diversity index was lowest in the *Salix koreensis* community at 0.09. This community include a few species, the covers of *Oenanthe javanica*, *Persicaria thunbergii*, *Artemisia princeps* var. *orientalis*, *Rumex crispus*, *Phragmites japonica Steud*, *Stellaria aquatica SCOP* were 1% with the barring dominant species *Salix koreensis*.

With respect to the dominant index, one community is 0.9, 13 communities are 0.3-0.7 and 15 communities are less than 0.3. The *Salix koreensis* community was the highest at 0.931, while the *Prunus sargentii-Pinus densiflora* community was the lowest at 0.13.

The species diversity index and dominance were inversely related; the dominant species of the highest community had the lowest species diversity index. The species diversity index and dominance was 0.13 and 1.09, Mt. Yongam in Kwangreung(Kim *et al*. 1995). The average heterogeneity was 0.32(range 0.23-0.37) from the

Table 1. Diversity index(H') and dominance index(C) of riparian plant communities in study site

Community	H'	S.D.	C	S.D.
Quercus mongolica Community	0.71	0.13	0.32	0.09
Pinus densiflora Community	0.73	0.18	0.32	0.17
Populus davidiana Community	0.75	0.14	0.31	0.11
Quercus variabilis Community	0.85	0.17	0.21	0.05
Prunus sargentii Community	0.82	0.14	0.23	0.07
Acer ginnala Community	0.72	0.05	0.31	0.01
Hemiptelea davidii Community	0.59	0.11	0.52	0.09
Carpinus laxiflora Community	0.86	0.30	0.24	0.17
Pyrus pyrifolia Community	0.85	0.18	0.25	0.12
Juglans mandshurica Community	0.87	0.04	0.22	0.08
Magnolia sieboldii Community	0.53	·	0.51	·
Fraxinus mandshurica Community	0.71	·	0.34	·
Fraxinus rhynchophylla Community	0.98	·	0.13	·
Malus baccata Community	0.94	·	0.17	·
Quercus serrata Community	0.82	·	0.22	·
Rhus verniciflua Community	0.74	·	0.33	·
Tilia mandshurica Community	0.61	·	0.32	·
Ulmus macrocarpa Community	0.60	·	0.42	·
Carpinus laxiflora-Prunus sargentii Community	0.52	·	0.39	·
Pinus densiflora-Quercus variabilis Community	0.85	·	0.21	·
Pyrus pyrifolia-Fraxinus rhynchophylla Community	1.05	·	0.14	·
Prunus sargentii-Pinus densiflora Community	1.10	·	0.13	·
Prunus sargentii-Quercus serrata Community	0.98	·	0.15	·
Prunus sargentii-Ulmus macrocarpa Community	0.91	·	0.20	·
Pourthiaea villosa-Pterostyrax hispida Community	0.89	·	0.16	·
Salix gracilistyla Community	0.80	·	0.23	·
Salix koreensis Community	0.09	·	0.93	·
Salix koriyanagi Community	0.46	·	0.47	·
Salix rorida Community	0.57	·	0.32	·

river to the inland(Han *et al*. 2013). The degree of slope is the most important aspect to improve species diversity of river plant communities.

Armesto *et al*.(1991) stated that the species' richness in a population and the space pattern of the dominance of each species were determined by the interaction of the biological properties and non-biological characteristics.

The species diversity is influenced by several kinds of environmental factors; the height of tree layer and the percentage of vegetation cover, and the shrub layer(Figure 5-Figure 16).

Gradient reports were researched to establish the relation between species diversity index and dominance compared to independent variables and dependent variables in order to find influential factors correlating the species diversity index and dominance.

In the relational formula, the species diversity index and shrub layer percentage of vegetation cover, was shown with a normal distribution relation(r=0.319).

Strong light rays have an effect on the primary growth of a seedling for physiological activity including the photosynthesis and moisture characteristics.

In addition, if the quantity of light is reduced below a certain level, the growth rate is greatly reduced(Choi etc, 2002) and is relatively disadvantageous without the proper light environment(Choi, 2001).

The species diversity index increases, when the gradient becomes steeper. According to Lee and Cho(2000), the moisture percentage, organic matter and total nitrogen are inversely proportional to the gradient and proportional to the soil's pH.

However, Lee(1999) noted that a site which is steeper

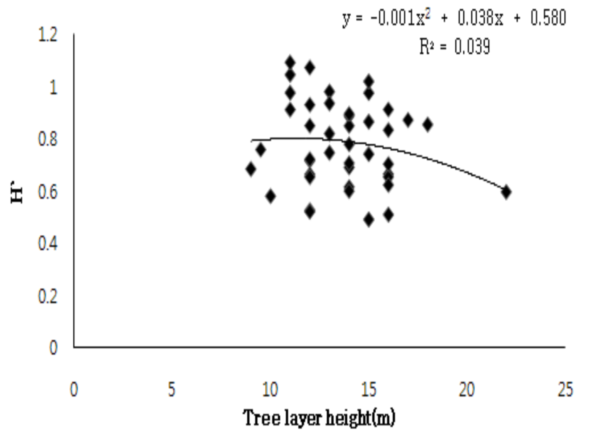

Figure 5. Relation between diversity index(H') and tree layer height

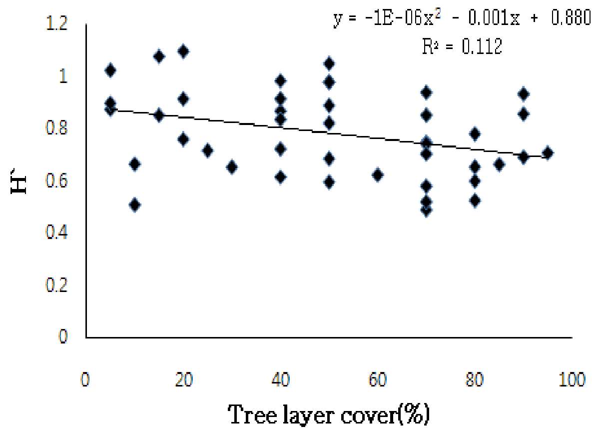

Figure 6. Relation between diversity index(H') and tree layer cover

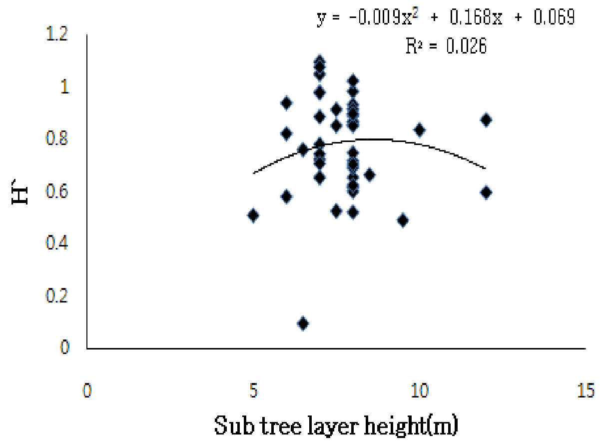

Figure 7. Relation between diversity index(H') and sub tree layer height

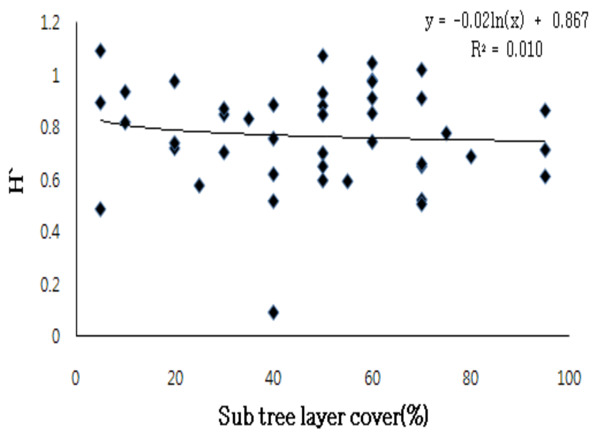

Figure 8. Relation between diversity index(H') and sub tree layer cover

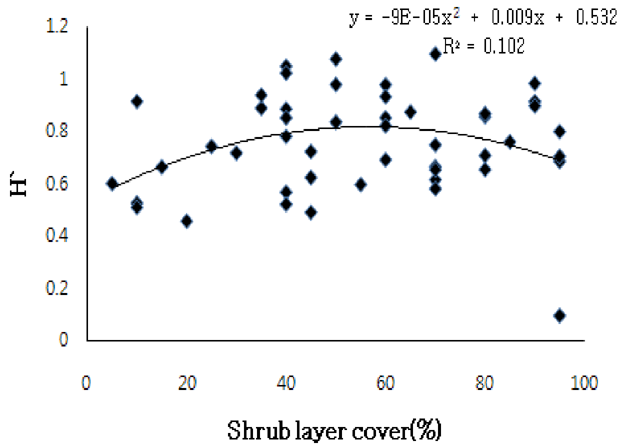

Figure 9. Relation between diversity index(H') and shrub cover

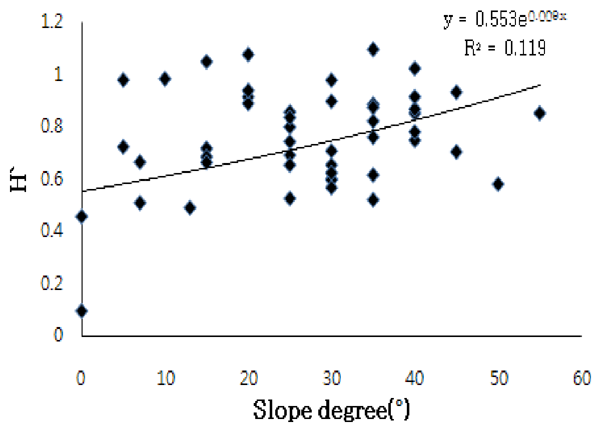

Figure 10. Relation between diversity index(H') and slope degree

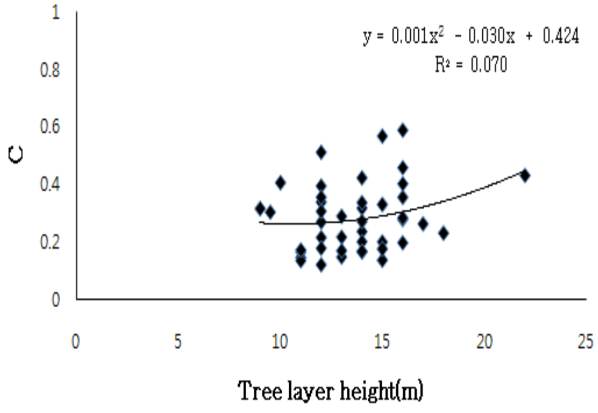

Figure 11. Relation between dominance index(C) and tree layer height

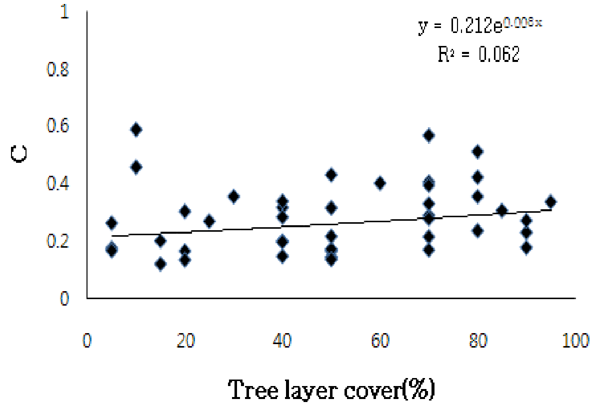

Figure 12. Relation between dominance index(C) and tree layer cover

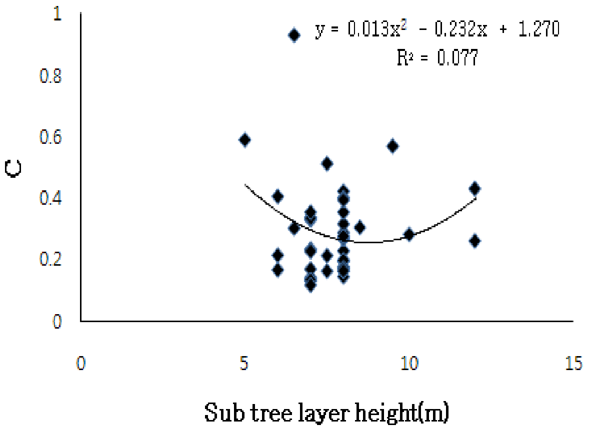

Figure 13. Relation between dominance index(C) and sub tree layer height

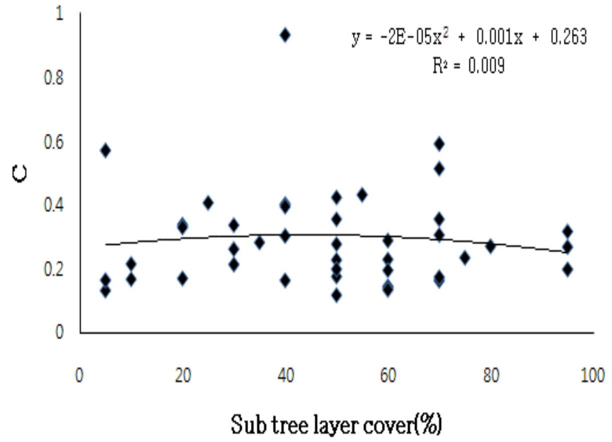

Figure 14. Relation between dominance index(C) and sub tree layer cover

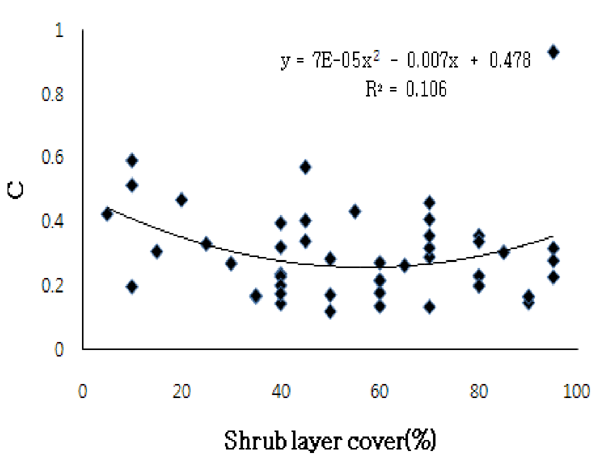

Figure 15. Relation between dominance index(C) and shrub cover

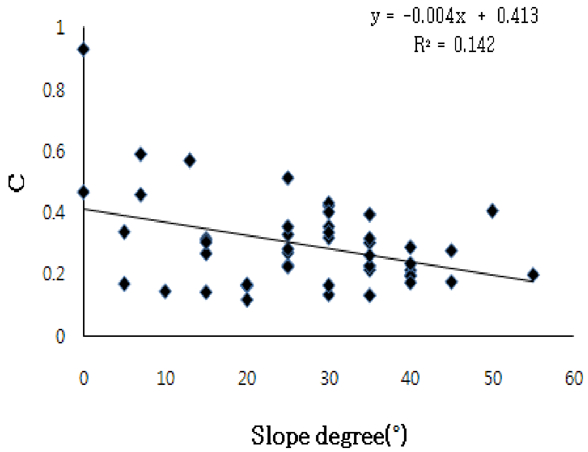

Figure 16. Relation between dominance index(C) and slope degree

than a gradient 40 ° has a higher moisture percent, organic matter, total nitrogen, Avail P_2O_5, C.E.C and low pH, which differs from Choi(2000).

Generally, it's well known that as the gradient becomes steeper, moisture percentage and organic matter usually decrease. Therefore, gradient changes are one of the environmental factors which affect the distribution of communities. As the gradient increases up to 30 °, the dominance starts to decrease gradually and over 30 ° it tends to increase sharply.

Consequently, the diversity of species and dominance are affected by the gradient and other factors do not feature in other relational expression. As a result, we see that species diversity index and dominance are significantly changed in accordance with some environmental factors.

However, it's very difficult to determine specifics from this theory, because of many other factors also contribute including the complexity of the structure and size of populations, the relation between nutrients and light, scarce soil sources, countermeasures of plants in order to get light and so on(David, 1988).

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