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Effect of Species Diversity on the Stability of the Plant Community in and around the Secret Camp on Mt. Paektu

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Abstract We researched various kinds of plant communities and evaluated the effect of species diversity on the community stability in and around the secret camp on Mt. Paektu.
In study area, the main communities are Picetum-Abiosum, Betuletum-Picosum-Abiosum, Betuletum-Alnosum, Betuletum-Calamagrostosum, Rhododendrotum, Papavetum-Hedysarosum, Vaccinetum-Arctosum and Rhodioletum. And the climax forest is a spruce forest of *Picea jezoensis* and *Abies nephrolepis*, and the succession forest is *Betula ermanii*-spruce forest. It is also important to evaluate the dominance index to characterize the stability of communities in different stages.
Key words Mt. Paektu, plant community, species diversity, community stability

Introduction

The great leader Comrade **Kim Il Sung** said as follows.

"Biological study must be oriented in every way to better protection for and effective use of the existing fauna and flora, so that the people can benefit substantially." ("**KIM IL SUNG** WORKS" Vol. 20 P. 465)

Mt. Paektu, which is registered as the International biosphere reserve and the national priority area of biodiversity, has a closely growing virgin forest. Therefore, it has a great scientific value throughout the northeast Asia and the world as well as in our country.

In the past it has made a progress to investigate flora and plant community of Mt. Paektu throughout the world as well as our country[3].

Recently, the main topic of the forest ecosystem research is to determine the stability of plant community. The main methods to investigate the stability of community were to estimate the composition of the species, coverage rate and the density of population according to the layer, estimate the renewal state and find out whether it was the climax forest or the succession forest. Many researchers have studied the stability of community with primary products, material cycle and present biomass. However, it requires times and costs, therefore some researchers study the stability of community by comparing diversity index[5, 6]. In this case, the discussing problem is whether there is negative correlation or positive one between diversity and stability. In other words, if diversity is high, stability is higher or not. The opinions on this problem are not still agreed, however, many of researchers believe that it is reasonable to accept diversity index to estimate stability.

We researched kinds of plant community and evaluated the effect of species diversity on the community stability in the secret camp on Mt. Paektu which was set up as the standard research place.

1. Study Area and Methods

1.1. Study Area

Study area is 1 600～2 150m above the sea of Jong Il peak, Saja peak and Mt. Sobaek in the secret camp on Mt. Paektu, which is situated on the course of the Amnok River, the west of Mt. Paektu. The annual average temperature is –1.4℃ and annual precipitation is about 1 000mm.

1.2. Study Methods

We divided community according to dominant species and evaluated composition and species diversity[1, 2].

The indexes such as Shannon diversity index (H'), Shannon equivalence index (J') and Simpson dominance index (C) are used in evaluating the diversity [4].

$$H' = -\sum P_i \ln(P_i) \tag{1}$$

$$J' = H' / \ln S \tag{2}$$

$$C = \sum P_i^2 \tag{3}$$

where $P_i = n_i / N$, n_i is individual number of i species, N is total number of individuals and S is number of species.

We compared diversity indexes and found the effect of species diversity on community stability.

We used altimeter("BARIGO ALTIMETER"), digital camera, ruler, computer and so on.

2. Results

2.1. Kinds of plant community in the secret camp on Mt. Paektu

We can divide communities into Picetum-Abiosum, Betuletum-Picosum-Abiosum, Betuletum-Alnosum, Betuletum-Calamagrostosum, Rhododendrotum, Papavetum-Hedysarosum, Vaccinetum-Arctosum and Rhodioletum.

2.1.1. Picetum-Abiosum

This community, which is indeciduous coniferous tree in sub alpine zone consisting of *Picea jezoensis* and *Abies nephrolepis*, was distributed at 1 600～1 780m in north, northwest, west, southwest and northeast incline of Jong Il peak and at 1 600～1 800m in west, southwest, southeast and east incline of Saja peak and Mt. Sobaek. The structure and abundance are shown in table 1.

The ratio of *Picea jezoensis* and *Abies nephrolepis* is 5∶5 in Jong Il peak and 6∶4 in Saja peak and Mt. Sobaek, respectively.

Vertical structure has three layers: primary layer(trees) of *Picea jezoensis* and *Abies nephrolepis*, second layer(shrubbery) of *Sorbus amurensis*, *Acer barbinerve*, *Syringa wolfi*, *Rosa davurica*, *Acer ukurunduense* and *Acer tegmentosum,* and third layer(herb) of *Streptopus koreanus*, *Maianthemum dilatatum*, *Calamagrostis langsdorffii*, *Thalictrum tuberiferum*, *Clintonia udensis* and *Geranium dahuricum* and so on.

Table 1. Structure and abundance of Picetum-Abiosum

Layer	Species	Abundance	Layer	Species	Abundance
Ⅰ	*Picea jezoensis*	cop^3	Ⅲ	*Smilacina davurica*	cop^1
	Abies nephrolepis	cop^3		*Clintonia udensis*	cop^1
Ⅱ	*Sorbus amurensis*	cop^1		*Cimicifuga foetida*	cop^1
	Acer barbinerve	cop^1		*Calamagrostis langsdorffii*	cop^1
	Syringa wolfi	cop^1		*Thalictrum tuberiferum*	cop^1
	Rosa davurica	cop^2		*Carex lanceolata*	sp
	Acer ukurunduense	sp		*Orthilia parvifolia*	sp
	Acer tegmentosum	sol		*Majanthemum bifoliu*	sp
Ⅲ	*Streptopus koreanus*	cop^1		*Geranium dahuricum*	sol
	Maianthemum dilatatum	cop^1			

Degree of species saturation per one hundred square metres in Jong Il peak(14～16) is higher than the one in the other regions(11～13). This is because that Jong Il peak has a micro climate by surrounding with higher mountains such as Saja peak and Mt. Sobaek and therefore it consists of variety flora in alpine grassland, sub arctic zone and north temperate zone.

2.1.2. Betuletum-Picosum-Abiosum

This community, which is distributed at 1 600～1 700m in east, southeast, south and southwest incline of Jong Il peak and at 1 600～1 850m in east, southeast, southwest incline of Saja peak and Mt. Sobaek, is hemi-evergreen forest with *Picea jezoensis* and *Abies nephrolepis* of 60%.

The dominance species are *Betula ermanii*, *Picea jezoensis* and *Abies nephrolepis* and the company species are trees such as *Larix oligensis*, *Picea koraiensis*, *Sorbus amurensis*, *Acer barbinerve* and *Syringa wolfi,* and grasses such as *Pedicularis respinata* var. *oppositifolia*, *Maianthemum dilatatum* and *Oxalis acetosella*(table 2).

Table 2. The structure and abundance of Betuletum-Picosum-Abiosum

Layer	Species	Abundance	Layer	Species	Abundance
Ⅰ	*Betula ermanii*	cop^2	Ⅱ	*Weigela florida* form. *leucanth*	sol
	Picea jezoensis	cop^2		*Spiraea blumei*	un
	Abies nephrolepis	cop^2		*Pedicularis respinata* var. *oppositifolia*	cop^3
	Picea koraiensis	sol		*Majanthemum dilatatum*	cop^2
	Larix oligensis	un		*Carex siderosticta*	cop^1
Ⅱ	*Sorbus amurensis*	cop^1	Ⅲ	*Calamagrostis langsdorffii*	cop^1
	Acer barbinerve	cop^1		*Oxalis acetosella*	cop^1
	Syringa wolfi	cop^1		*Clintonia udensis*	sp
	Rosa davurica	cop^1		*Streptopus koreanus*	sp
	Lonicera caerulea var. *emphyllocalyx*	cop^1		*Phlomis koraiensis*	sp
	Acer ukurunduense	sp		*Orthilia parvifolia*	sol
	Rhododendron dahuricum	sp			

Here, degree of species saturation per one hundred square meters is 18～20. It was higher than Picetum-Abiosum. We considered that this community was the one in the transition step and made a condition for more plants to enter than in spruce community.

2.1.3. Betuletum-Alnosum

This community has *Betula ermanii* and *Alnus maximowiczii,* the main superiority species and therefore it can be considered as the community of the deciduous broadleaf high trees in sub arctic zone.

It was distributed in the top at 1 750m of Jong Il peak and at 1 750～2 150m in northwest and southeast of Saja peak and Mt. Sobaek. *Alnus maximowiczii* was more sparse than *Betula ermanii* in south slope rather than north incline. This is due to that *Betula ermanii* is photophily plant, but *Alnus maximowiczii* is shade-tolerant one.

It has 4 layers: primary of *Betula ermanii* and *Alnus maximowiczii*, second of *Sorbus amurensis* and *Acer barbinerve*, third of *Rosa davurica* and *Echinopanax elatum* and the last of *Clintonia udensis*, *Oxalis acetosella, Majanthemum dilatatum* and *Pedicularis respinata* var. *oppositifolia*(table 3).

Table 3. The structure and abundance of Betuletum-Alnosum

Layer	Species	Abundance	Layer	Species	Abundance
Ⅰ	*Betula ermanii*	cop^3	Ⅲ	*Rhododendron dahuricum*	sol
	Alnus maximowiczii	cop^3		*Weigela hortensis*	un
Ⅱ	*Betula plantyphylla*	sp	Ⅳ	*Clintonia udensis*	cop^2
	Acer barbinerve	cop^1		*Synurus deltoids*	cop^1
	Sorbus amurensis	sp		*Oxalis acetosella*	cop^1
Ⅲ	*Rosa davurica*	sp		*Majanthemum dilatatum*	sp
	Syringa wolfi	sp		*Pedicularis respinata* var. *oppositifolia*	sol
	Echinopanax elatum	sp		*Boschniakia rossica*	sol

2.1.4. Betuletum-Calamagrostosum

This community was composed of 10% of *Betula ermanii* and *Calamagrostis langsdorffii,* and *Betula ermanii* distributed in top and steep gradient incline at 1 780m above of south and westsouth of Jong Il peak and at 1 900～2 000m of Mt. Sobaek and Saja peak.

It has two layers(table 4). In Jong Il peak, the degree of crown contact is low as about 0.2 and the coverage rate is 80% above, especially nearly 100% in south west.

Table 4. The structure and abundance of Betuletum-Calamagrostosum

Layer	Species	Abundance
Ⅰ	*Betula ermanii*	sp
	Abies nephrolepis	sol
Ⅱ	*Calamagrostis langsdorffii*	soc

This community occupy low ration throughout all study area and has a boundary line with alpine grassland zone. It has a scientific significance in studying the change pattern of thimber line.

In addition, there were Rhododendrotum, Papavetum-Hedysarosum, Vaccinetum-Arctosum and Rhodioletum.

2.2. Effect of species diversity on stability of plant community

We decided that climax forest is spruce one and succession forest is *Betula ermanii*–spruce one in study area and evaluated diversity at quarts in typical sites reflecting these characters.

Data was divided into three parts: Jong Il peak, Saja peak and Mt. Sobaek and total area. First, we investigated species diversity of climax forests and succession forests in Jong Il peak. The results are shown in table 5.

Table 5. Value of diversity indexes of climax and succession forests in Jong Il peak

Sort	Number of species(S)	Diversity index(H')	Equivalence index(J')	Dominance index(C)
Climax forest	13	2.08	0.81	0.15
Succession forest	24	2.51	0.79	0.10

As shown in Table 5, the value of diversity index in climax forest is smaller(about 0.5) and the value of dominance index is larger than in succession forest. However, value of equivalence index was similar.

Next, we investigated species diversity of climax forests and succession forests in peripheral sites of Jong Il peak such as Saja peak and Mt. Sobaek(table 6).

Table 6. Value of diversity indexes of climax and succession forests in peripheral sites of Jong Il peak

Sort	Number of species(S)	Diversity index(H')	Equivalence index(J')	Dominance index(C)
Climax forest	11	1.34	0.56	0.37
Succession forest	18	1.92	0.67	0.21

Also, the values of diversity index between climax forest and succession one are different(about 0.6). That is, value of succession forest is larger than climax one. On the contrary, value of dominance index of climax forest is higher.

Table 7 shows the values of diversity indexes of total study area. The value of species diversity index of succession forest(2.38) is much higher than climax forest(1.84). The value of dominance index is contrary(climax forest is 0.24 and succession forest is 0.13). The value of equivalence index is a little larger than in the succession forest.

Table 7. Value of diversity indexes of climax and succession forests in total study area

Sort	Number of species(S)	Diversity index(H')	Equivalence index(J')	Dominance index(C)
Climax forest	15	1.84	0.68	0.24
Succession forest	27	2.38	0.72	0.13

From these results, we can see that species diversity index in climax forest is lower than in succession forest. On the contrary, dominance index is larger. Value of equivalence index didn't show distinguished difference. So we can say that our results are more consistent with May[6], who believed that the larger the value of dominance index is, the more stable the community is, than with MacArthur and Huchinson[5], who considered that diversity induce stability, the more diverse the community is, the more stable the community is, and diversity is ratio with the degree of equivalence.

In order to see it in production power, we measured and compared the diameters of breast height(*DBH*) of *Betula ermanii, Picea jezoensis* and *Abies nephrolepis* in *Betula ermanii* forest, spruce forest and mixed forest, respectively(Fig. 1－3).

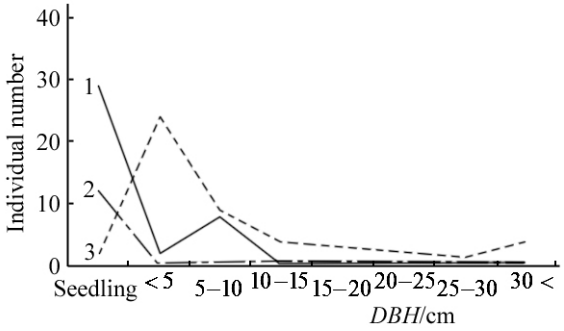

Fig. 1. Distributional character in *DBH* of some species in *Betula ermanii* forest
1－*Picea jezoensis*, 2－*Abies nephrolepis*, 3－*Betula ermanii*

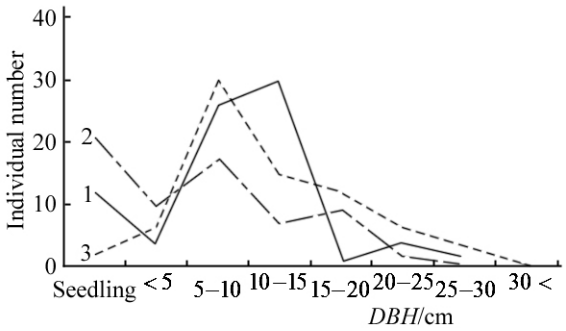

Fig. 2. Distributional character in *DBH* of some species in mixed forest
1－*Picea jezoensis*, 2－*Abies nephrolepis*, 3－*Betula ermanii*

As shown in Fig. 1, 2 and 3, the natural virgin forest of spruce changes from *Betula ermanii* forest to *Betula ermanii*-spruce forest and then spruce forest. And the succession forest is mixed forest and the state of dominance species in each community reflects the stability of its community.

From this, we considered that it is reasonable to evaluate the stability of community by using the value of dominance index.

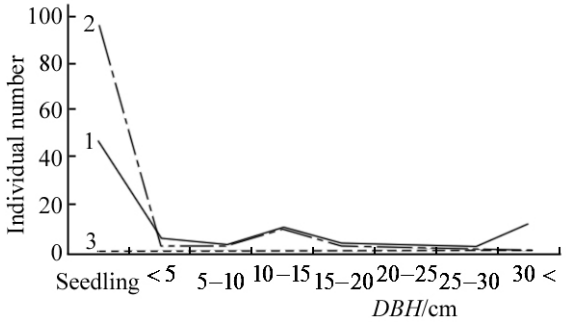

Fig. 3. Distributional character in *DBH* of some species in spruce forest
1－*Picea jezoensis*, 2－*Abies nephrolepis*, 3－*Betula ermanii*

Conclusion

We reviewed the effect of species diversity on the stability of forest plant community by analyzing the values of diversity index.

It is reasonable to evaluate the value of dominance index in estimating the stabilities of communities in stages of different changes.

We think it is more suitable that diversity increases in inverse proportion to dominance rather than in proportion to the degree of equ ce.ivalen

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