Interspecific Association and Stability of *Thuja koraiensis* Community

Hui Jin, Xiang Jia, Hang Yin, Yuhong Dai, Lijie Liu, Ying Liu, Runlin Wang, Ying Zhao* and Liwu Qin*

Jilin Provincial Joint Key Laboratory of Changbai Mountain Biocoenosie an Biodiversity, Changbaishan Academy of Science, Yanbian, Jilin, 133613, China

*Corresponding author's e-mail:
*zhaoying19801108@126.com(Ying Zhao)
*278778656@qq.com(Liwu Qin)

Abstract. Interspecific association is one of the important quantitative and structural characteristics of plant community. Analyzing interspecific association and stability of community is of great ecological significance to understand community structure, dynamics and classification. The community survey was carried out in 3 flowing sample plots in *Thuja koraiensis* community to analyze the interspecific relationship and stability of the community. The results showed that the overall association of *Thuja koraiensis* with tree layer species and shrub layer species in *Thuja koraiensis* community-variance ratio (VR) was higher than one, showing significant positive correlation. The ratio of the reciprocal cumulative percentage of species and the cumulative relative frequency in the 3 flowing sample plots was far away from 20/80, indicating that all the *Thuja koraiensis* communities were in an unstable state, and the stability of P2 sample plot was greater. *Thuja koraiensis* community has not yet reached a stable stage, so it is urgent to strengthen the protection of them.

Keywords: *Thuja koraiensis*, Overall association, interspecific association, stability.

1 Introduction

Thuja koraiensis, an evergreen arbor of Cupressaceae Thuja, is an endemic species in the flora of Changbai Mountain. The natural distribution of Thuja koraiensis is narrow, which is mainly distributed at the altitude of 600-2000m in the narrow zone of southwestern slope of Changbai Mountain area. It is an endangered species in *CHINA SPECIES RED LIST* [1], belonging to the second class national protected plant. It is difficult for *Thuja koraiensis* to regenerate naturally, so its population is rare. In recent years, due to deforestation and habitat destruction, the number of wild resources has sharply decreased, almost endangered. The survival situation of Thuja koraiensis has been widely concerned at home and abroad.

W. He et al. (eds.), *Proceedings of the 2024 10th International Conference on Advances in Energy Resources and Environment Engineering (ICAESEE 2024)*, Atlantis Highlights in Engineering 36,
https://doi.org/10.2991/978-94-6463-708-3_26

Interspecific association and the stability of its community are effective methods to study endangered species mechanism, reveal plant population, competition status and community succession. [2]The objective measurement of species' spatial connectivity can not only describe the spatial distribution and resource allocation of species under habitat conditions and biological characteristics [3], but also reflects the adaptability to the environment and the population dynamics of plant community in habitats. At present, there is no report on interspecific association and stability of Thuja koraiensis community. In this paper, based on a survey of the population of *Thuja koraiensis* in Changbai Mountain area, the interspecific association and stability of the main woody plants of *Thuja koraiensis* community was analyzed to reveal its role in the endangered formation mechanism of the minimal population of *Thuja koraiensis*.

2 Research Area and Research Method

2.1 Natural Environment

The research area is located in Changbai Mountain area, Jilin, China. The zonal climate of this area belongs to the continental mountain climate with monsoon influence. It is cold and dry in winter; warm and moist in summer. Precipitation is mostly concentrated in July and August. The annual average temperature is 4.4 °C, with extreme maximum temperature of 37.5 °C and extreme minimum temperature of -40 °C. The annual precipitation is 600-1340 mm, and the relative humidity is above 70%, with a frost-free period of 90-100 days.

2.2 Research Method

Sample Plot Setting and Data Collection. In 2023, Three plots of 30m×30m were established in *Thuja koraiensis* community. The species, crown width, coverage and DBH of woody plants with DBH≥1.3cm were investigated and recorded in detail. The sample area is summarized in Table 1.

Table 1. Community habitat and vegetation status in survey area.

Forest type	Altitude/m	Geographic coordinates	Crown density
P1	1383	N127°59′36″E41°41′04″	0.72
P2	1476	N128°04′34″E41°46′00″	0.85
P3	1870	N127°56′26″E41°45′03″	0.70

Data Processing. The association between multiple species was simultaneously determined by the variance ratio method (VR), and statistics W was used to test the association between multiple species. The calculation formula could be found in the References[4].Based on 2×2 contingency tablet, a comprehensive analysis of the nature and degree of species pair association were made using the Yates correction coefficient formula based on chi-square test, combined with the point correlation coefficient (PCC), association coefficient (AC), Ochiai association index (OI), percentage cooccurrence(PC) and other measurement indicators[5]. These values can explain the degree of positive association between species, which reflects the consistency of the ecological habits and environmental of the two species.[6]

Community Stability Index. The stability of the Thuja koraiensis community was determined by the modified M.Gordron stability determination method [7]. The smooth curve model is $y = ax^2 + bx + c$. The equation of the line is $y = 100 - x$. Excel and IBM SPSS Statistics 26 software were used to analyze the data.

3 Results and Analysis

3.1 Overall Association Among Multiple Species of Thuja Koraiensis Community

Table 2 shows the multi-species interspecific association coefficient was VR>1, indicating that there was a positive correlation among species in general. Using the statistics W to detect the degree to which the VR value deviated from 1, W=7.1628 was obtained. From the table, W was not in the range (23.269, 50.998), indicating there was significant positive correlation of the overall association between species.

Table 2. Overall association analysis among species of *Thuja koraiensis* community.

Forest type	σ_T^2	S_T^2	VR	W	$\chi^2_{0.05}(N)$, $\chi^2_{0.95}(N)$	Overall association
P1	3.585	6.834	1.906	68.629	(23.269,50.998)	Significant positive correlation
P2	2.500	7.394	2.957	106.445	(23.269,50.998)	Significant positive correlation
P3	4.107	6.541	1.593	57.342	(23.269,50.998)	Significant positive correlation

3.2 Analysis of Interspecific Association

Interspecific association Between Thuja Koraiensis and Tree Layer Species. As can be seen from table 3, Thuja koraiensis and Acer ukurunduense, Larix gmelinii and Pinus koraiensis were positively correlated, only reaching a extremely significant level with Acer ukurunduense($p<0.01$). It is mainly due to similar biological characteristics and similar ecological adaptability to the habitat. Thuja koraiensis and 12 kinds of tree layer species such as Abies nephrolepis、Picea koraiensis and Tilia amurensis et al. were negatively correlated, only reaching a extremely significant level with Picea jezoensis var. microsperma.($p<0.01$). The majority were negatively correlated in the test, indicating that the ecological requirements of the 16 species were different to some extent.

Table 3. Correlation measure table of the paired species of the tree layer.

Main species	X^2	*AC*	*PCC*	*OI*	*PC*
Abies nephrolepis	0.006	-0.014	-0.012	0.541	0.370
Picea koraiensis	4.680	-0.676	-0.145	0.048	0.013
Acer ukurunduense	21.548	0.429	0.281	0.563	0.376
Sorbus pohuashanensis	0.479	-0.116	-0.050	0.248	0.116
Acer tegmentosum	0.015	-0.027	-0.007	0.174	0.057
Betula costata	1.358	-0.172	-0.078	0.240	0.114
Picea jezoensis var.microsperma	22.026	-0.384	-0.284	0.257	0.144
Populus koreana	0.450	-0.027	-0.002	0.058	0.007
Pinus koraiensis	0.002	0.297	0.031	0.095	0.013
Acer barbinerve	2.853	-0.381	-0.113	0.123	0.043
Betula ermanii	2.515	-0.207	-0.102	0.246	0.122
Acer mono	0.001	-1.000	-0.061	0.000	0.000
Larix gmelinii	0.993	0.486	0.080	0.174	0.040
Acer komarovii	1.336	-0.514	-0.089	0.058	0.013
Tilia amurensis	0.561	-1.000	-0.086	0.000	0.000

Interspecific Association Between Thuja Koraiensis and Shrub Layer Species. As can be seen from Table 4, 7 species-pairs revealed positive association, and 9 species-pairs revealed negative association. According to the ochiai association index between *Thuja koraiensis* and shrub species, the OI value of 1 pair (*Euonymus macropterus*) was more than 0.3, 8 pairs was between 0.1and 0.3, and 7 pairs was less than 0.1, indicating that the correlation degree between *Thuja koraiensis* and shrub layer species was low, and the distribution pattern was relatively independent. According to percentage cooccurrence (PC) value, the highest percentage cooccurrence value of *Thuja koraiensis* and *Euonymus macropterus* was 0.17.

Table 4. Correlation measure table of the paired species of the shrub layer.

Main species	X^2	*AC*	*PCC*	*OI*	*PC*
Euonymus macropterus	0.279	0.086	0.040	0.336	0.174
Actinidia kolomikta	0.118	0.314	0.045	0.134	0.027

Rubus sachalinensis	1.844	0.270	0.091	0.295	0.126
Tripterygium wilfordii	0.169	-0.222	-0.043	0.104	0.026
Rubus crataegifolius	0.449	-0.027	-0.002	0.058	0.007
Cerasus maximowiczii	0.449	1.000	0.081	0.116	0.014
Syringa wolfi	4.102	-0.583	-0.136	0.066	0.019
Euonymus verrucosus	0.449	-0.027	-0.002	0.058	0.007
Sambucus manshurica	0.449	-0.027	-0.002	0.058	0.007
Philadelphus schrenkii	0.251	0.486	0.056	0.123	0.020
Oplopanax elatus	0.569	-0.444	-0.072	0.062	0.013
Ribes mandshuricum	0.232	-0.351	-0.053	0.067	0.013
Viburnum koreanum	0.449	-0.027	-0.002	0.058	0.007
Lonicera caerulea	4.848	0.614	0.145	0.267	0.086
Rosa marretii	0.199	-0.270	-0.047	0.087	0.020
Linnaea borealis	0.450	1.000	0.081	0.116	0.014
Lonicera maximowiczii	1.373	-0.351	-0.085	0.106	0.032

3.3 Analysis of Community Stability

The results of community stability analysis are shown in Table 5. The ratio of the reciprocal cumulative percentage of species and the cumulative relative frequency in the 3 flowing sample plots was far away from 20/80, indicating that all the *Thuja koraiensis* communities were in an unstable state, and the stability of P2 sample plot was greater.

Table 5. Analysis of Community stability(M. Godron).

Forest type	Curve types	Determina-tion coefficient R^2	p	Euclide-an distanc e	Results
P1	$y=-0.0101x^2+1.8579x+10.236$	0.990	$p<0.01$	22.6	instability
P2	$y=-0.0106x^2+1.8645x+15.835$	0.984	$p<0.01$	19.1	instability
P3	$y=-0.0106x^2+1.8645x+15.835$	0.988	$p<0.01$	22.5	instability

4 Conclusion

4.1 Interspecific Association and Succession Direction of Community

The association analysis of the Thuja koraiensis community showed that the overall species association index VR > 1, and the overall association of the community was positively correlated. The positive and negative correlation among species implies the function of species in the community, and ultimately affects the community succession. Therefore, the analysis of the interspecific association of the community is helpful to better understand the succession direction of the community. [8]Negative association is caused by different preference for the environment or competition. In general, mature and stable communities often show more positive association to achieve the stable coexistence of species. [9]

4.2 Factors Affecting the Stability of Thuja Koraiensis Community

Different populations within a community regulate their mutual relationships through competition, symbiosis and other means, eventually leading the community to a state of dynamic equilibrium.[10] The stability of plant community is influenced by interspecific competition, environmental pressure and interference activities and other factors.[11]. It is a complicated ecological process from population association to community stability. In the study of the living conditions of Thuja koraiensis, if we put the population association and community stability together, the conclusions of the two can confirm each other, which is of great practical significance. The analysis of community stability in this study shows that the *Thuja koraiensis* community is in a relatively unstable state, which is mainly due to human activities. The exploitation of resources has caused irrecoverable damage to *Thuja koraiensis* community, resulting in the continuous decrease of the population and the destruction of the community. Although the overall correlation of the community is positive, the community is still in an unstable state according to the interspecific association and the stability index.

4.3 Conservation Strategies

Thuja koraiensis is a rare and endangered plant. In recent years, its population number and distribution range have been decreasing. It is urgent to take effective measures to protect *Thuja koraiensis*. Human activities are the main factors affecting the survival and development of *Thuja koraiensis.* On the basis of in-situ conservation, artificial auxiliary measures should be carried out to promote the propagation of *Thuja koraiensis*. Proper planting of plants which are positively connected with *Thuja koraiensis* will contribute to the stability of *Thuja koraiensis* community.

Acknowledgments

This research was financially supported by the Scientific and Technological Development Project of Jilin Province, China (Grant No. 20220101327JC and Grant No. 2024010218JC).

References

1. Wang S and Xie Y 2004 *China Species Red List*, Vol.1.(Beijing).
2. Zhou SX, Peng YS, Ding JM, Gao PX, Li GL, Wang M and Lü F 2017 *Guihaia* 37 442–448.
3. Jiang J and Zhao X H 2011 *Scientia Silvae Sinicae* 47 149-153.
4. Jin H, Yin H, Li J N, Zhao Y, Qin L W, Li X J, Zhao F G and Zhao W 2014 *Journal of Beihua University (Natural science)* 15 792-797.
5. Jian M F, Liu Q, Zhu D, et al 2009 *Chinese Journal of Plant Ecology* 4 672-680.
6. CÁRDENAS RE, VALENCIA R, KRAFT NJB, et al 2014 *Journal of Ecology* 102 939–952.
7. Zheng YR 2000 *Sci Silv Sin* 36 28-32.
8. Jin J Y,Qin W G,Tan W N,et al 2013 *Journal of West China Forestry Science* 42 86-94.
9. Zhang R H 2006 *China Forestry Science and Technology* 20 24-27.
10. AMYNTAS A, BERTI E, GAUZENS B, et al 2023 *Functional Ecology* 37 2652-2665.
11. Lu G H,Du X,Yang J J,et al 2007 Arid Land Geography 30 660-665.