Temporal and Spatial Succession Law of Abor Diversity in Xiaoxing'an Mountains

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Abstract. The national forest nature reserve in the Xiaoxing'anling area was studied. Based on the diversity of $\alpha$ and $\beta$, three forest types of grassland, birch forest, and larch forest were analyzed. Based on the diversity law of latitude gradient, the nature reserve was discussed in forest type. A difference in a diversity of different forest types was succession changes. A method based on quantitative evaluation of species conservation value was constructed. The community structure and species composition of nature reserves were systematically analyzed, and the conservation value of species and the conservation value of rare and endangered species were scientifically evaluated. The results showed that the Shannon Wiener index and Margalef index of grassland, birch forest, and larch forest showed a decreasing trend with the increase of latitude. Compared with the other four latitudes, the grassland, birch forest and larch forest of Dazhanhe Nature Reserve showed a decreasing trend from the north to south Jaccard index and Sorenson index, and the Cody index showed an increasing trend. The Jaccard index and the Sorenson index have peaks in friendly areas, and the species similarity is high, indicating that the friendly areas may be the interlaced areas of Xiaoxing'anling. The Shannon Wiener index and the Margalef index of the nature reserve from the early stage of succession to the middle and late succession increased continuously, reaching the maximum in the middle and late stages, and began to decline in the later stage of succession, which is consistent with the mid-specie.

1. Introduction

The nature reserve is the most abundant area in the nature reserve due to relatively light disturbance[1]. It is the core of China's biodiversity conservation. However, due to the development of modern commercialization and related laws and regulations, management is not perfect[2]. The destruction of the internal ecological environment has occurred from time to time. The data show that the current extinction rate is 1000 times faster than the rate of natural extinction, and 10% of the world's species are facing extinction, because each species has a certain ecology in the ecosystem[3]. The extinction of species has caused the community structure to change, affecting the changes of habitats and the structure and function of ecosystems[4]. Therefore, it is urgent to carry out the investigation of forest plant diversity in nature reserves and scientifically evaluate the value of species conservation[5-6]. The benign development of biodiversity is achieved. Crucial number of protected areas, the unified evaluation system, the assessment of the protection value of protected areas, and the prioritization of protection order are particularly important for the protection of biodiversity[7-8]. Choosing reasonable
evaluation indicators and standards, evaluating the conservation value of nature reserves, determining the priority of protection is of great significance, and can also provide theoretical basis and scientific basis for the effective protection and management of nature reserves in the Xiaoxing'anling area. Changes in habitat conditions will lead to changes in plant structure and function, and environmental factors have an important impact on species distribution and diversity[9]. It mainly includes topographic factors, soil factors, climatic factors, and biological factors. Globally, climatic conditions, and topography are the main factors affecting community species diversity. The research, conservation and sustainable use of species diversity are the core content of biodiversity, and the distribution pattern of species diversity along the time and space dynamics has always been one of the hot issues in ecological research. It can not only distinguish areas with different degrees of diversity. It also reveals the relationship between species richness and environmental gradients, species evolution, and migration. At present, it is generally believed that the main factor causing the difference in community diversity is the heterogeneity of habitat between communities. Therefore, the variation of species diversity along the latitude gradient and community succession is discussed, which is helpful to understand the composition and distribution pattern of forest community structure. This study will deeply explore the distribution pattern and formation mechanism of species diversity in the above aspects, and provide a theoretical basis for the benign development of protected areas and the effective protection of biodiversity.

2. Materials and methods

2.1. Experimental plot
The Xiaoxing'anling is located in the north-central part of Heilongjiang Province. It is a temperate monsoon climate. It is bounded by the Heilongjiang River in the north, Sanjiang Plain in the east, and Songnen Plain in the west. It is an important gateway to the northeastern frontier. The east-west width is 210km, the north-south length is 450km, the forest area is more than 5 million hm², the forest cover rate is 72.6%, and the annual precipitation is between 550~700mm. The four seasons are distinct, the winter is cold and dry, and the summer is warm and humid. The stock of red pine is very rich. With the succession of ecological communities and the destruction of modern forests, various secondary forests have been formed. The current tree species mainly include coniferous and broad-leaved mixed forest, Mongolian oak, larch forest, spruce-fir forest, Populus euphratica secondary forest, broad-leaved Korean pine forest, and birch forest. It is rich in plant resources and is a treasure trove of biodiversity in northern China.

2.2. Materials and methods
The sample plots and surveys are selected in the protected area to select the neat and representative sections of the forest to avoid the selection of forest windows and traces caused by human and natural disturbances. The area of the plot is generally 30m×30m. For the forest community type of the riparian community, the direction of the river is 10m×40m, the small community sample is generally 20m×20m, and the shrub community is 10m×10m. For each plot, ten 1m×1m herbaceous squares, ten 2m×2m shrub-like squares, and 36 5m×5m arbor-like squares were set. A total of 296 plots were set up, and the species protection assessment used GPS to record the geographic coordinates and altitude of the survey location. The growth characteristics of each species were recorded in each plot during the survey. Herbs are averaged according to their number (cluster herbs are counted according to their number of clusters), and the number, type, coverage and frequency are counted. Shrubs are investigated according to the type, quantity and crown width. According to the survey, the species, quantity, breast diameter, coverage, crown width and other indicators.

2.3. The diversity of Species measurement method

\[
H' = - \sum_{i=1}^{s} P_i \ln P_i
\]
Species uniformity index: \( E = H / \ln S \)  

Species dominance index: \( C = \sum_{i=1}^{S} N_i / N (N - 1) \)  

Species richness index: \( D_{\text{neg}} = L (S - 1) / \ln N \)

Note: The H’ means the Shannon-wiener index; the E means the Pielou index; the C means the Simpson index; the DMG means the Margalef index; the S means the number of the species; the Pi means the ratio of the number of individuals in the ith species in the community, the N means the total number of individual samples, \( Pi = N_i / N \); the \( N_i \) means the number of individuals of the ith species.

The \( \beta \)-diversity uses the Cody index (\( \beta C \)) based on binary attribute data, and the \( \beta \) diversity index \( C J \) and \( C S \) using the similarity coefficient Jaccard and the Sorenson index to calculate.

\[
\beta_c = \frac{b + c}{2a^2} \\
Jaccard index = a(a + b + c); \quad C_J = \frac{a}{2a} \\
Sorenson index; \quad C_s = \frac{(2a + b + c)}{(2a + b + c)}
\]

Note: The “a” means the number of species shared in the plots; the “b” means the number of species lost along the habitat slope, and the number of species present in the previous gradient but not in the next gradient; \( c \) is the number of species increasing along the habitat gradient; the number of species present in the next gradient in the absence of the previous gradient.

2.4. Data analysis

Data were organized using Office Excel 2007, and SPSS 22.0 software was used to analyze the data by one-way ANOVA and LSD.

3. Results and discussion

3.1. Based on latitudinal gradient diversity

Based on latitude gradient grassland, birch forest, larch forest, diversity of forest plant community, the formation of environmental gradient differentiation pattern is related to the different degree of response of different community layer and growth type to environmental factors. The diversity of three growth types of trees, shrubs and herbs was analyzed. With the increase of latitude, the Shannon wiener index and Margalef index of grassland, birch forest and larch forest showed a decreasing trend. The Margalef index showed a decrease and then increased. The Shannon Wiener index of grassland, birch forest and larch forest were significantly different between the northernmost Shengshan area and the southernmost Dazhanhe area (P<0.05). The Margalef index of the Dazhehe area and the Wuyiling area was significantly different (P<0.05).

3.2. Derivation of \( \alpha \)-diversity based on latitudinal gradient species

Based on the variation of latitudinal gradient diversity and the latitude gradient, we found that the CJ, and CS of grassland, birch forest and larch showed a decreasing trend, the similarity of the population became lower, and the three forest types appeared in the friendly place. The obvious peaks, CJ and CS index are all larger, which shows that plant communities with different latitudes of the same forest type have great differences between plant species composition and community habitat.

Table 1. Grasscard, birch forest, larch forest’s Jaccard index, Sorensen index, Cody index

|            | 1# PLOT | 2# PLOT | 3# PLOT | 4# PLOT | 5# PLOT | 6# PLOT |
|------------|---------|---------|---------|---------|---------|---------|
| MEADO      | CJ      | 0.145   | 0.143   | 0.071   | 0.235   |         |
3.3. Based on latitude gradient α-variety variation law

The α-diversity of habitats is also called diversity, that is based on the diversity condition of species consisting of community structure; diversity pattern is mainly used for the reaction within a particular community or a location thereof. The diversity index of grassland, birch forest, and larch forest were significantly different at the low latitude and high latitude (P<0.05). Shannon-Wiener index and richness index was negatively correlated with latitude, indicating that water and nutrients increased with latitude. The uneven distribution of temperature and light provides a niche for different environmentally preferred species, causing changes in the heterogeneity of the community habitat, which exacerbates the intensity of competition among species. That is, habitat filtration leads to changes in community diversity and community productivity. The uniformity index showed a decreasing trend, and the dominance index showed an increasing trend. The overall fluctuation was not large. This may be because some plants with low tolerance were difficult to adapt to habitat conditions and exit the community as the temperature decreased, and the habitat conditions changed.

Table 2. Typical random plots preserve the α diversity of forest community succession

|          | PLOTS-1 |          |          |          |          |          |
|----------|---------|----------|----------|----------|----------|----------|
|          | Grass   | Birch forest | Larch Forest | Bushes   | Oak      | Korean Pine   |
| H’       | 1.71±0.36b | 2.39±0.23ab | 3.12±0.19a | 2.69±0.11ab | 2.76±0.23a | 2.30±0.34ab |
| E        | 0.71±0.13a | 0.87±0.17a | 0.80±0.18a | 0.69±0.13a | 0.79±0.34a | 0.71±0.12a |
| C        | 0.29±0.33a | 0.22±0.14a | 0.23±0.13a | 0.21±0.18a | 0.09±0.21a | 0.21±0.17a |
| D_MG     | 1.70±0.51b | 3.34±0.21ab | 4.20±0.21a | 3.33±0.23a | 4.02±0.12ab | 4.12±0.29ab |
|          | PLOTS-2 |          |          |          |          |          |
|          | H’       | 3.04±0.39b | 3.03±0.22ab | 3.67±0.12a | 3.09±0.21ab | 2.68±0.32ab | 2.51±0.23ab |
| E        | 1.02±0.12a | 0.81±0.21a | 0.87±0.12a | 0.81±0.11a | 0.69±0.13a | 0.69±0.32a |
| C        | 0.21±0.23a | 0.23±0.13a | 0.12±0.11a | 0.21±0.12a | 0.22±0.23a | 0.21±0.23a |
| D_MG     | 1.98±0.27c | 2.69±0.51bc | 3.63±1.13ab | 4.49±0.39a | 4.50±0.41a | 4.20±0.60a |

3.4. Based on the latitudinal gradient β diversity evolution law

β diversity is used to show the difference in species composition between different communities. It is the degree of substitution of species along the environmental gradient under different habitat conditions. Therefore, measuring the variation of β diversity among communities can reveal the extent of species division. Deterministic processes and stochastic processes may have an impact on β diversity. The main role of certainty based on niche theory is in environmental filtration and biological interaction, while stochastic processes appear as interference and species elimination. The rate is
related to the rate of colonization.

Table 3. Shengshan forest community substitution β multi-repetitive change

|                | Birch forest | Larch Forest | Bushes | OAKR | Korean Pine |
|----------------|--------------|--------------|--------|------|-------------|
| Cj  | Poplar Forest | 0.512        | 0.532  | 0.490 | 0.501        | 0.339        |
|     | Birch forest  | -             | 0.339  | 0.410 | 0.398        | 0.452        |
|     | Larch Forest  | -             | -      | 0.501 | 0.398        | 0.379        |
|     | Weeds          | -             | -      | -     | 0.469        | 0.298        |
|     | Bush forest    | -             | -      | -     | -            | 0.289        |
| Cs  | Poplar Forest  | 0.599        | 0.601  | 0.702 | 0.465        | 0.598        |
|     | Birch forest  | -             | 0.620  | 0.558 | 0.581        | 0.612        |
|     | Larch Forest  | -             | -      | 0.603 | 0.632        | 0.560        |
|     | Weeds          | -             | -      | -     | 0.639        | 0.469        |
|     | Bush forest    | -             | -      | -     | -            | 0.460        |
| βC  | Poplar Forest  | 30.121        | 29.876 | 25.989 | 28.590      | 33.909       |
|     | Birch forest  | -             | 32.123 | 32.498 | 31.796      | 32.498       |
|     | Larch Forest  | -             | -      | 30.110 | 29.490    | 37.897       |
|     | Weeds          | -             | -      | -     | 23.491      | 37.998       |
|     | Bush forest    | -             | -      | -     | -           | 42.490       |

3.5. Community Succession forest α diversity change

This study used spatial substitution time method to analyze the diversity variation law in the forest succession of Xiaoxing'anling National Nature Reserve. The middle and late stage community mixed forest and the early succession of grassland and the later succession of the coniferous and broad-leaved mixed forest Shannon-dimensional. The nano-index, uniformity index and Simpson's index were all significant (P<0.05). The uniformity index and Simpson's index of coniferous and broad-leaved mixed forests and grassland and Korean pine forests were significant (P<0.05) and 5 protected areas. The Shannon-Wiener index and the richness index increased from the early stage of succession to the middle and late stages of succession, reaching the maximum in the middle and late stages, and began to decline in the later stage of sequence, which is basically consistent with the mid-species rich holiday. The uniformity index and the Simpson index did not fluctuate as a whole, and the species richness and uniformity of the climax community were lower than the previous period, while the Simpson index was higher than the previous period.

Table 4. The Dazhan River forest community replaces β with repeated changes

|                | Birch forest | Larch Forest | Bushes | OAKR | Korean Pine |
|----------------|--------------|--------------|--------|------|-------------|
| Cj  | Poplar Forest | 0.471        | 0.466  | 0.446 | 0.456        | 0.377        |
|     | Birch forest  | 0.122        | 0.400  | 0.346 | 0.361        | 0.330        |
|     | Larch Forest  | 0.345        | 0.011  | 0.365 | 0.405        | 0.351        |
|     | Weeds          | -             | -      | -     | 0.427        | 0.508        |
|     | Bush forest    | -             | -      | -     | 0.356        | 0.352        |
4. Conclusions

The evolution of community structure and habitat environment, species diversity and community stability are constantly changing. By comparing the diversity of the Xiaoxing'anling Nature Reserve in the process of community succession, we found that the Shannon-Wiener index and the Margalef index increased from the early succession to the sequence in the middle and later stages, reaching the maximum in the middle and late stages, and in the later stage of succession. It has a downward trend and is generally a single peak model. The uniformity index and the dominance index did not fluctuate as a whole. The richness and evenness of the species in the current climax community stage were lower than those in the previous period, indicating that species diversity is only the basis or necessary condition for community stability. Diversity index and richness of different types of communities in Xiaoxing'anling plot. This study based on the quantitative construction of species conservation value evaluation method can better reflect the difference in conservation value of different protected areas and protection priority. By comparing the diversity of grassland, birch forest and larch forest at different latitudes, and the diversity changes in community succession, we found that $\alpha$ and $\beta$ diversity can explain the distribution pattern of biodiversity well, and the environment is different. Qualitability is a key factor in promoting species coexistence and diversity. The forest national nature reserves are in different succession stages. Although the results of this study are limited to the typical communities in the protected areas, the conservation value evaluation method of the species can better reflect the differences in the conservation value of different protected areas and the priority of conservation. By introducing the number of individuals of rare species, the protection of rare species value evaluation is more reasonable and comprehensive.

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