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Effects of planting ginseng on understory vegetation species diversity in eastern Liaoning Province, China

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Abstract—**The ownership of property of collective owned forest in eastern Liaoning Province, China, has been transformed from collectivity owned to farmers owned, and the transfer has brought many different woodland management methods. Planting ginseng is the main management method which was developed before the transfer and will be more popular in the future. Floristic surveys were performed in 4 different forests under different planting methods for ginseng in Fushun City which is the main ginseng planting area of eastern Liaoning Province, China, to assess the impact of planting ginseng on understory vegetation species diversity. This impact was evaluated through analyzing species richness, species evenness and species diversity. The purposes of this study were to test (1)have there been changes for understory vegetation species diversity in the areas with planting ginseng?(2)do different planting methods take different changes to understory vegetation species diversity, and (3) which method will be suitable for the development of forests in eastern Liaoning province? Our results showed that ginseng planting had greatly destroyed the shrubbery and reduced the species richness of herbage in all sites. In terms of species evenness, we only found a decreasing for index J in Larch forest with MM and increasing for all other sites. This study also expressed that the species diversity of understory herbaceous vegetation was changed differently among different sites. Our finding suggests that planting ginseng in broad-leaf mixed forest with the NG method which means the ginseng will be in natural growth without human management after seeding is the best choice for the development of forest and economical profit of farmers.**

Index Terms—**anthropogetic disturbances, biodiversity, forest development, ginseng**

I. INTRODUCTION

Sustainable forestry involves the extraction of forest products while maintaining the integrity of ecosystem to conserve biodiversity and to provide other non-commodity benefits to society [1], and the conservation of biodiversity-the variety of life in an area-is globally recognized as a fundamental component of ecologically sustainable forest management [2]. Many factors such as environment, disturbance, and ownership have a great impact on biodiversity of forest[3]，and understanding how biodiversity of forest will change in response to forest management is a major theme to forest researchers. To date, most studies that considered this issue have been conducted on overstory managements such as harvest and forestation [4], and the differences between the understory communities of post-agricultural and undisturbed forests have been widely documented in both Europe and the US [5-6]. Many researchers paid more attention to the potential effects of forest policies on biodiversity in multi-ownership area in US and Australia [7-8], but focused on overstory vegetation. Until recently, far less attention has been given to understanding how the biodiversity of understory vegetation of forest was impacted by woodland managements in China, despite the methods and areas of woodland management both being on growing trend.

Anthropogetic disturbances can result in a profound and prolonged impact on forest vegetation [9]. Several studies in Europe and North America have shown that richness of herbaceous forest species was reduced [10-12] and vascular plant species composition and diversity were altered [13-15]. Past land use influenced both short-and long-lived species [16], and the floristic composition of both the understory and overstory differed considerably even after several decades of regeneration [17]. Although previous human activity can affect the entire plant communities, herbaceous understory plants are among the most sensitive taxa to historic disturbance due to their limited mobility, low recruitment, and short seed dormancy [18], they represent a key group for conserving biodiversity [19]. Understanding the impacts of anthropogetic disturbances on understory vegetation remained an important challenge to forest ecologists and managers [20].

The forests of mountain areas in eastern Liaoning province are important reservoirs of biodiversity in Liaoning Province, China, and main woodland management area of China. Woodland management here has formed a special agroforestry with planting economics crops such as medicine crops and potherbs in forest systems [21]. Most woodland managements here began in the 1980s and developed in the 1990s. They were mainly performed in collectivity owned forests. The ownership of property of collective owned forests in China began to be transferred from collectivity to farmer in 2005. Until 2008, the transfer of ownership of the collectivity owned forests were finished. Changes of ownerships have caused different management statuses because of the different purposed of farmers. In this context, the aim of this study was to examine the woodland

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management with the largest planting areas in Liaoning Province, planting ginseng (Panax ginseng) on the understory vegetation species diversity of forests. We used the biodiversity indices computed by basic dataset describing the understory vegetation composition gained from plot survey to analyze:

1) Have there been changes for understory vegetation species diversity in the areas with planting ginseng?
2) Do different planting methods take different changes to understory vegetation species diversity?
3) Which method will be suitable for the forest development of eastern Liaoning province?

II. MATHOD

A. Study area

Our surveys were conducted in Fushun City which located in eastern Liaoning Province. The study areas (123°39´N — 125°28´N and 41°41´E — 42°38´E) is the stretching parts of Changbai mountain. The altitude varies between 400 and 500m above sea level and is characterized by a Humid monsoon climate, with an mean annual rainfall 750mm to 850mm which mainly occur in July - September. The mean annual temperature is around 7℃ and the relative humid is between 64% and 72%. The soils are dark brown forest soil and brown forest soil. The total forest area of the study area is 675 km2. Forests of the region are mainly composed of natural secondary forest and plantation which are used for protecting water resource and producing wood products. The forest types include Korean pine (Pinus koraiensis) forest, Larch (Larix olgensis) forest, Chinese pine (Pinus tabulaeformis) forest, and broad-leaf mixed forest.

Planting methods for ginseng the study area are determined by farmers and mainly divided into two types: natural growth without management after seeding (NG) and manual management during the life times of ginseng (MM). Fields were cleared before seeding for the both two management methods and shrubberies and herbages were all removed, but there was no need to cut the trees.

This study chose Larch (Larix olgensis) forest and broad-leaf mixed forests as the main sites because they were the man areas that ginseng planted in. We examined three representative planting regions of ginseng, that were planting ginseng(Panax ginseng) in Larch forests with NG method, in broad-leaf mixed forests with NG method and MM method.

B. Data collection

The ecological survey was performed between June and September in 2008 in three planting regions. We selected 4 sites (20m×20m) from the three regions and arranged the locations and numbers depending on the management conditions [22]: 1 site in Larch forests with NG method, 2 site in broad-leaf mixed forests with NG method of with different years of ginseng and 1 site in broad-leaf mixed forests with MM method (Table 1). Each site was divided into two secondary sites, site a and site b: a was managing site (MS) with woodland management and site b was natural site (NS) without woodland management. For G2 and G3, they were conducted in the same forests type with same natural condition, and they were with the same NG site, b2. In each secondary site, 10 plots (2m×2m) were placed following a Z-shape design, total number of plot was 50. In each plot, we counted and recorded shrubbery and herbage species conditions including species name, number, height and coverage, but ignored the tree species because it would not affect tree development to perform woodland plantation and management.

C. Statistical analysis

Based on the obtained data, we used species richness, species evenness and species diversity to reflect the differences between MS and NS in each site. The indices included Shannon-wiener diversity index（H′）, Simpson diversity index (D), Pielou index (J), species number(S) and Margalef index (D_{Ma}). Each index was expressed as follow [23-27]:

Shannon-wiener diversity index（H′）:

$$H^{'} = -\sum_{i=1}^{s} p_i \ln p_i \quad (1)$$

Simpson diversity index (D):

$$D = 1 - \sum_{i=1}^{s} p_i^2 \quad (2)$$

Pielou index (J):

$$J = (1 - \sum_{i=1}^{s} p_i^2)/(1 - 1/S) \quad (3)$$

Margalef index (D_{Ma}):

$$D_{Ma} = (S-1)/\ln N \quad (4)$$

Where, s was the number of species; N was the total number or all species; Pi was the importance value of each species, it was calculated by:

Pi = (relative number value + relative height value + relative coverage value)/3 (5)

The relationships between MS and NS were tested by T test using SPSS 11.0 [28].

Tab.1 natural condition of study site

site		Altitude (m)	Latitude	Longitude	Aspect	Gradient (°)	forest type	management method	Years (yr) *
G1	a1	584	41°52′	125°11′	northeast	15	Mixed	NG	10
	b1	584	41°52′	125°11′	northeast	15	Mixed	—	—
G2	a2	534	41°32′	124°47′	northwest	25	Mixed	MM	12
	b2	534	41°32′	124°47′	northwest	25	Mixed	—	—

G3	a3	534	41°32′	124°47′	northwest	25	Mixed	MM	8
	b2	534	41°32′	124°47′	northwest	25	Mixed	—	—
G4	a4	596	41°52′	125°11′	northeast	15	Larch	NG	10
	B3	596	41°52′	125°11′	northeast	15	Larch	—	—

*Years means the years for management, and years for all site b are absent because all site b are comparison sites which have no management.

III. RESULTS

A. *Changes of species diversity in shrubbery layer*

1) Changes of species diversity in NG sites

Each species diversity index was reduced in all NG sites (G1 and G4) which were with no human management activities after the ginseng were planted (Fig. 1). In the MS of site G4 we investigated, 10 shrubbery species were found but none in NS, and the changes of shrubbery in site G4 was not display in Fig. 1.There were obviously decreased for indices DMa, S, H and D, and little for index J. We could get the change rate shown in table 2 which was gained through divided the changes of NS and MS by NS. The change rate for species evenness index J was only 0.66% from NS (b1) to MS (a1) which was form 0.8624 to 0.8457 in site G1, and for other indices were larger than 30%. There were significant differences for most indices between NS and MS in the both sites from the results of T test ($p < 0.05$) except index J of site G1($P > 0.05$) (Table 3).

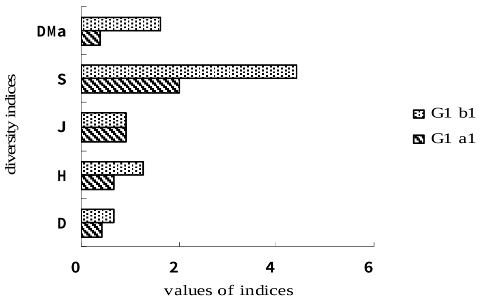

Fig.1 Changes of species diversity indices of shrubberies in NG sites

2) Changes of species diversity in MM sites

Great changes have occurred in MM sites, and no results were shown in table 2 for the vegetation of shrubbery in MM sties because fewer shrubbery have been found in MS of MM sites and the values of indices were 0. The species richness, evenness and diversity of the sites with planting ginseng were also significantly reduced by human management activities during the life time of ginseng. Taking site G2 as an example, in site NS we found many shrubbery species such as Viburnum sargenti, Philadelphus schrenkii, Lonicera maackii, Syringa reticulata, Actinidia kolomikta, Rubus crataegifolius, Crataegus sanguinea, Corylus mandshurica，and some young trees with DHB< 2cm, such as Juglans mandshurica, Acer triflorum, Tilia amurensis, Acer mono. The average species richness was 5 per square meter, but we only found 1 Syringa reticulata and 1 Actinidia kolomikta. In site G3, no shrubbery species were found.

B. *Changes of species diversity in herbage layer*

1) Changes of species diversity in NG sites

Species diversity indices of herbage were reduced in NG sites from NS to MS except index J in G1 which was a little increased (Fig.2). Species richness were evidently reduced in NG sites because the most significant reductions were occurred in index S for site G1 and index DMa for site G4. For example, in site G1 the rate of reduction of index S was 23.08% and less than 13% for other indices, and it was increased for index J; the rate of reduction of index DMa was 26.11% in site G4 (Table 2). Changes were not significant for indices between NS(b1) and MS(a1) in site G1 ($p > 0.05$) except index S ($P < 0.01$), but significant for index D ($P < 0.05$)and index J($P < 0.01$) in site G4 from the results of T test (Table 3)

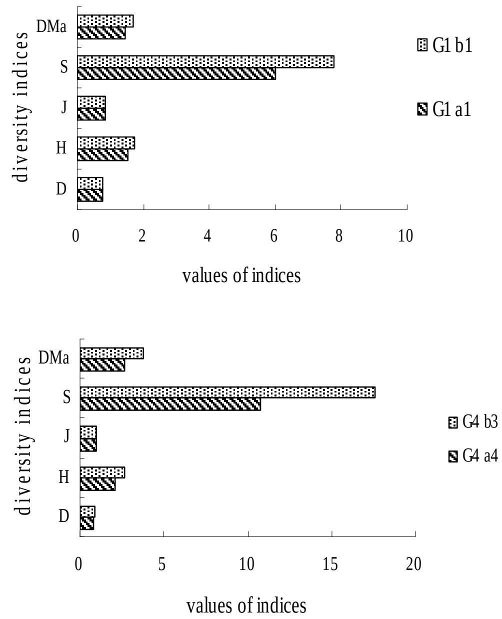

Fig.2 Changes of species diversity of herbages in NG sites

2) Changes of species diversity in MM sites

The changes of species diversity indices of herbages in MM sites including the different years of ginseng were shown in Fig. 3. Analyzing each vegetation index of herbage separately of all MM sites, it was observed that from NS to MS of all MM sites the species richness indices S and DMa and species diversity index H were reduced, and species evenness index J and species diversity index D increased as shown in table 2. Only the changes of index H of the two sites were not significant ($P > 0.05$), changes for other indices were all significant ($P < 0.05$) of each site(Table 3).

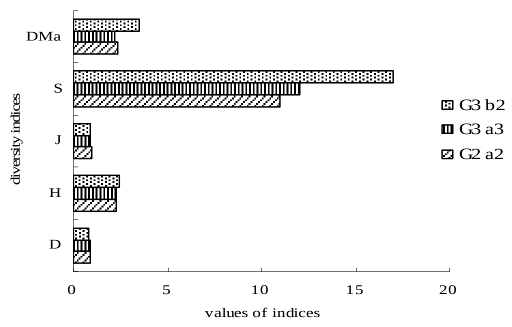

Fig.3 Changes of species diversity of herbages in MM sites

Table 2 Changes rate of species diversity (%)

site		D	H	J	S	D_{Ma}
G1	shrubbery	34.92	47.20	0.66	54.55	75.86
	herbage	1.26	10.01	-1.97	23.08	12.41
G2	herbage	-5.04	2.25	-16.34	35.29	30.89
G3	herbage	-4.37	1.78	-12.56	29.41	35.09
G4	herbage	16.43	16.52	13.70	5.41	26.11

Table 3 P values of biodiversity indices for each site

site		P				
		D	H	J	S	D_{Ma}
a1-b1	shrub	0.002	0.008	0.832	0.012	0.004
	herbage	0.703	0.772	0.772	0.003	0.130
a2-b2	herbage	0.013	0.310	0.000	0.005	0.005
a3-b2	herbage	0.023	0.341	0.033	0.009	0.000
a4-b3	herbage	0.026	0.270	0.008	0.764	0.142

IV. DISCUSSION

C. Have there been biodiversity changes in and between sites?

This study has shown that changes have occurred in all three measures of biodiversity investigated (species richness, species evenness and species diversity) in all sites and between sites of different management methods. In general, managing sites (MS) contained fewer species than natural sites (NS). This were observed in both shrubbery and herbage, results that concur with similar studies [29-30] , suggesting that planting ginseng influenced the entire understory vegetation of forests. Species richness was the most influenced species character, and significantly reduced for the ginseng planting. However, species evenness for index J of MM sites were changed higher in MS than in NS and were not significantly, and species diversity indices of most sites were not significantly changed. Zhang thought species diversity was affected by both species richness and species evenness [31], our result supported this conclusion.

D. Do different planting methods take different changes to understory vegetation species diversity and which method would be suitable for development of forests?

The changes rates of different biodiversity indices for different rate showed that species richness were all reduced, but the changes for species evenness index and species diversity indices were not identical(table 2). Planting ginseng would destroy the shrubbery badly, especially for planting in MM sites because none shrubbery species was left. Greater changes for herbage also have occurred in MM sites because more human managements were performed in than in NG sites. All understory vegetation was cleared before seeding for planting ginseng, and soil needed to be tedded for several days. These human managements would destroy the understory vegetation for the first time. It needs at least 10 years for ginseng which can be gained, and the vegetation can get recovered in NG sites during the 10 years because they grow in natural condition without any anthropogetic disturbances. However, the vegetation in MM sites do not get enough recovery because continuous weeding, shrubbery lopping and fertilization were performed for assisting the ginseng growth. For the planting method, MM can bring worse sequences to understory vegetation than NG and it is not suitable for the development of forests. NG is better choice.

We also could draw the conclusion that different changes have existed between the two NG sites for one is in broad-leaf mixed forest and the other is in Larch forest. The change rates in G1 which was in broad-leaf mixed forest was smaller than in G4 which was in Larch forest as shown in table 1, all shrubbery species have disappeared in G4, but in G1 the species evenness was not significantly changed. The research of Chen et al showed that the ginseng planted in broad-leaf mixed forest could grow better than the one planted in Larch forest [22], and we could draw the conclusion that planting ginseng in broad-leaf mixed forest with NG method will be the best choice for the development of forest and can get best economical profit.

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