647-653
第19卷第5期
1999年9月

# 残次油松林群落特征与生物多样性恢复

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**摘要**:在河北省兴隆县雾灵山国家级自然保护区研究了经长期人为破坏的残次油松林的群落特征及其在不同保护年限 下的生物多样性恢复规律。研究表明、与正常林分相比,残次林的物种多样性指数大幅度降低,物种数量显著减少。在植 物和昆虫群落各项参数的变化中,以瀘木和天敌昆虫类群受影响最大。其科数分别减少 55.56%和 60%,科-种多样性指 数分别减少 30.1%和 60.72%。随保护年限的增加,植物群落呈现明显的规律性变化,在保护早期,科、种数无明显变化、 个体数大幅度增加、多样性指数略有降低,此期为个体数量恢复时期;保护中期、种数迅速增加、个体数减少、多样性指数 增加、因而、该期是物种的重要恢复时期;此后,科的组成变化明显,科数和科-种多样性指数显著增加。昆虫群落的变化 特别是,早期植食性昆虫的科、种、个体数均明显增加、随保护年限延长,所有类群的多样性指数持续增加、特别是保护中 期整个群落的科数及天敌昆虫类群的科、种数与多样性指数增加最为显著,分别增加了 28.26%、56.35%、44.8%和 38.97%、此期为昆虫群落得到最大程度的恢复时期、可见,在油松残次林的恢复过程中、10a 左右是群落恢复的关键时 期、近 20a 可接近未受破坏的水平。

# 关键词:群落特征;生物多样性恢复;油松林

Community characteristics of degraded Chinese pine stands and their biodiversity restoration

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Abstract, The community characteristics of degraded Chinese pine (Pinus tabulae formis Carr.) stands which were damaged for a long time (23 years) by mankind and the restoration of their biodiversity after different years (2,5,11 and 19 years) of protection were studied. Investigations showed that the numbers of species in the degraded stands were obviously reduced and their diversity indices were significantly lower compared with that in the stands without damage. For the variation degrees of plant and insect groups, shrub and natural enemy insect groups were mostly affected with decreases of 55.56% and 60% in family number, and 30.1% and 60.72% in family-species diversity indices. With the prolonging of protection, plant community was found changed regularly. In the early period of protection ( $2\sim5$  years), the numbers of family and species showed no obvious changes, number of individuals significantly increased, and the diversity indices decreased slightly. In the middle period of protection (11 years), species numbers increased sharply, the number of individuals decreased, and the diversity indices raised, so this period was featured mainly with species restoration. After this, the compositions of families changed a lot, the family numbers and family-species diversity indices significantly increased. The features for the changes of the insect community were that, in the early protection period, all the numbers of family, species and individuals increased together with the obvious increment of phytophagous insect groups, and that, the species diversity indices of all the groups increased continuously with stand protection featuring in considerable increases of the numbers of family and species and diversity index of the natural enemy insect group in the middle prorection period.

Foundation item: The research is financed by National Science Foundation of China Received date: 1997-05-10 Key words:community characteristics;biodiversity restoration;Chinese pine stand 文章编号:1000-0933(1999)05-0647-07 中团分类号:S718.55+3 文献标识码;A

A large area of degraded Chinese pine stands has been formed in the northern mountainous areas of Hebei Province due to the overpruning, overcutting and overgrazing in the past decades. These stands possess the characteristics of obovious changes in community composition, significant decline in biodiversity and community unstability. And these stands are often found as the outbreak base of many pests like pine caterpillar. However, some degraded stands have been restored in biocommunity through artificial protections. Therefore, to study the affected community of the degraded stands and the variation patterns in community diversity restoration of the protected stands are rather important in studying the stable mechanism of community, in searching for the protection ways for biodiversity, in analyzing the community causes of pest outbreaks, and in perfecting the theories for integrated pest control.

### 1 Methods

#### 1.1 Location of investigations and stand status

The investigations were carried out in Wulingshan State Nature Reserve in Xinglong county of Hebei Province. Different stands of Chinese pine as the degraded stands, normal stands (no damaged) and the degraded stands with various years of protection were selected in this research. These stands have similar basic status such as stand age, site type and distance from the residential areas. The basic status of the different stands are listed in table 1.

No.	Elevation (m)	tion Distance from the Ag		Protection status	Protection year
1	1050	4.5	35	no protection, serious damage	0
2	1252	6.0	32	under protection, no damage	25
3	1140	6. 5	33	short period of protection	2
4	980	4.0	35	short period of protection	5
5	1200	7.0	34	middle period of protection	11
6	1100	6. 0	36	long period of protection	19

Table 1	Basic status of	various	Chinese	pine	stands
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## 1.2 Sampling methods

Investigations were carried out in the above stands from 1990 to 1995. In each stand, 2 sample plots of  $30 \times 30m$  were established. In each sample plot, 5 sample points of  $3 \times 3m$  were set up. During investigation, the species, heights and number of plants together with species and numbers of insects in each sample point were recorded. Meanwhile, 200 nets were taken randomly in a stand to catch insects, and their species and numbers were recorded.

## 1.3 Statistics

For the calculation of diversity index, the formula of Shannon-Weiner  $H' = \sum P_i \ln P_i$ , was used. In the diversity index of family-species,  $P_i$  indicates the ratio of the species number of family to the total species number. In the diversity index of vertical structure,  $P_i$  indicates the ratio of individual numbers at *i* layer height to the total individual numbers.  $\beta$  diversity index was calculated with Cody Index:  $\beta_i = \lfloor g(H) + l \\ (H) \rfloor/2$ . In the formula g(H) indicates the number of increased species and l(H) indicates the number of decreased species along with the environmental gradient.

# 2 Results and analysis

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### 2.1 Community characteristics of degraded Chinese pine stands

Firstly, investigations were given to the degraded stands with many years of human damage (No. 1) and to the normal stands with no damage (No. 2). Then, their community characteristics were compared. It was found that the species, individual number and diversity of both plants and insects between the two kinds of stands were obviously different. Investigation results are shown in table 2 and table 3.

Table 2	Comparison	of 1	plant	community	characteristics	between	the	degraded
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and normal Chinese pine stands

Plant type	Stand type	Family number	Species number	Individual number	Species diversity index	Family-species diversity index	Diversity index of vertical structure
Whole	Degraded	18	36	2180	1.8347	2. 0930	0. 4218
Community	Normal	34	67	2056	2-3679	2.9458	1.3691
Bush	Degraded	4	5	226	1.3678	1.2424	0.8725
Plants	Normal	9	10	568	2.0720	2.1639	1.9621
Grass	Degraded	13	29	1386	1.4722	1.7866	0.5627
Plants	Normal	24	26	1217	2.5631	2-6033	1.8336

Table 2 shows that the family and species numbers of plant in the degraded Chinese pine stands were declined by 47.06% and 46.27% respectively compared with the normal stands. All the diversity indices were also reduced obviously. Howevet, their individual numbers had no significant difference. The results show that many years of human damage to the stands resulted in environment deterioration, and that the species of adaptable plants decreased with domination by only a few plant families. The variation patterns of bush and grass plants under the trees were that all the community indices in the degraded stands except the individual number of grass plants were lower than that in the normal stand. And the bush plants reduced the most, family number reduced by 55%, individual number by 60%. So that, long term damage to the community mostly affected the bush plants.

Insect	Stand	Family	Species	Individual	Species diversity	Family-species	
group	type	number	number	number	index	diversity index	
Community	degraded	25	47	717	2. 0416	1.5266	
	normal	55	89	782	3. 2762	2.8789	
Leaf-eating	degraded	10	16	383	1.8212	1.8975	
	normal	19	25	417	2.0378	2. 3687	
Sap-sucking	degraded	4	10	216	1.5679	1.2566	
	normal	11	17	204	1.9346	2.3645	
Predacious	degraded	3	6	27	1.2865	1. 8891	
	normal	9	14	51	2.3687	2.8675	
Parasitic	degraded	5	11	36	2.0122	1.6765	
	normal	11	25	69	3.0638	2.6970	
Others	degraded	3	4	25	_		
	normal	5	8	41	_		

Table 3 Comparison of insect community characteristics between the degraded and normal Chinese pine stands

For the variation of insect community, all the indices in the degraded stands were lower than those of the normal ones. Of which the family number and lamily-species diversity indices reduced the most. This indicates that long term human damage to the stands significantly alfected the insect community. As to the variation of different insect group, the reduction of family numbers was greater than species numbers and individual numbers, in which the predactous insects, parasitic insects and sap-sucking insects were found mostly reduced by 66.7%, 54.5% and 54.5%, respectively. Moreover, in the various insect groups, the diversity index of natural enemy insects was obviously reduced compared with those of phytophagous insects and others. This shows that the natural enemy insects are more easily affected by human damages to the stands.

## 2.2 a diversity variation of Chinese pine stands

In order to learn the restoration status of biodversity of the stands under human protections, comparative investigations were given to the Chinese pine stands with different years of closing and protection. 2.2.1 Diversity variation of plant community

Along with the prolongation of protected periods, plant community showed a regular pattern of variation. The results are shown in table 4. Results showed that, in the early period of protection, the numbers of family and species of plant had no obvious changes, individual numbers increased much, diversity index of plant species slightly reduced, diversity index of vertical structures slightly increased. These were directly related to the status of incompletely restored growth of Chinese pine in the early protection and to the unimproved environment of the whole stand. Of the increase of individual plant numbers, the plants in grass family increased mostly with a figure of 101%. These demonstrated that, in the early period of protection, the restoration of plant community was dominated with the increase of individual plant number, but not its composition.

	perious or protection										
Protected years	Family Specie number numb		Individual Species number diversity index		Family-species diversity index	Diversity index of vertical structure					
2	18	38	3211	1.1366	1. 9334	0- 5511					
5	18	42	3890	1.0478	1.8475	0.5899					
11	23	54	2864	2.0344	2-1698	0.9671					
19	31	62	2447	2.2617	2. 4771	1-2583					

 Table 4 Variation of plant community of Chinese plane with various

 periods of protection

For the stands with middle and long periods  $(11 \sim 19 \text{ years})$  of protection, their composition and deversity of plant community were found obviously changed. (1) The numbers of family and species significantly increased by 27.8% and 50.0% in the middle protection period respectively, and 72.7% for both numbers in the long protection period compared with those of degraded stands. Analysis shows that 61.5% of the increased family numbers occurred after closing of the middle protection period, and 69.2% of the increased species numbers was before this protection. This further indicates 10 years of protection. (2) The individual number of plant in the long protection period was decreased compared with that in early protection. This was resulted from the restoration of plant community and the improved environment in the stands. Also, shade-living plants increased, and the individual numbers of grass family which dominat-

ed in the early protection period started to decrease. (3) All the diversity indices were found significantly increased along with the prolonging of protection years. Of which, the diversity index of plant species increased much in the middle protection period, family-species diversity index increased mostly started from the period of middle protection. However, the diversity index of vertical structure showed a tendency of successive increase.

#### 2.2.2 Diversity variation of insect community

Investigations showed that insect community in the stands was also changed along with the diversity restoration of plant community. The results were given in table 5.

Table 5 shows that the variation tendency of insect community was similar to that of plant community along with the protected years to the stands. In early protection period, individual insect numbers showed slightly increase, but were down from middle protection period. However, the numbers of family and species obviously increased in early protection by 12.0% and 19.0% respectively. Diversity index also showed some increase. These indicated that insects were sensitive to the environmental changes. The increases of family and species numbers mostly occurred in the period of  $5 \sim 11$  years of protection to the stands, and family number changed significantly by 28.26%. This demonstrated that this period was most of importance for the restoration of insect community. Further analysis was given to the changes of various insect groups in the insect community, and the effects of environment on insect community were made clear. The variations are shown in table 6.

Table 6 shows that, in the early protection period, the increases of family, species and individual numbers of phytophagous insects were more than those of natural enemy insects, but the diversity index showed some decrease. In the middle period of protection, all the insect groups changed a lot. The family number, species number and diversity index of natural enemy insect group greatly increased by 56.  $25 \frac{1}{20}$ , 44.8% and 38.97 respectively compared with those of degraded stands. This indicates natural enemy insect group was mostly restored in this period. The effects of long time protection for the stands on the insect community provided successive increase in family number, species number and diversity index for all the insect groups, decrease in individual number of phytophagous insect, in further increase in individual numbers of natural enemy insects, turning to the high diversity of community, more serious control inside the community, and improvement in stability of the community.

Protected years	Family number	Family Species Individual number number number		Species diversity index	Family-species diversity index
2	28	56	1030	1.8386	1-7465
5	33	62	1121	2.0485	1-9471
11	46	78	896	2.8876	2.5773
19	51	85	923	3.9346	2.7219

 
 Table 5 Diversity variations of insect community in Chinese pine stands with different years of protection

2.3  $\beta$  diversity variation of Chinese pine stands

For the sake of analyzing the variation status of the community structure of Chinese pine stands in their restoration,  $\beta$  diversity indices of plant and insect communities were calculated with Cody Index at

different years of stand protection										
Protected years	Insect	Family number	Species number	Individual number	Species diversity index	Family-species diversity index				
5	Leaf-eating	14	20	589	1.5674	2. 0931				
	Sap-sucking	6	12	458	1.4034	1.6893				
	Predacious	5	8	26	1.8841	2.0181				
	Parasitic	6	13	37	2-3769	1.7731				
11	Leaf-eating	17	23	447	1.9936	2. 2094				
	Sap-sucking	9	14	336	1.6192	2.1375				
	Predacious	8	12	4]	2.1371	2.8011				
	Parasitic	8	17	50	2.5455	2.4936				
19	Leal-eating	19	24	425	2. 0228	2- 3378				
	Sap-sucking	10	15	371	1-7933	2-2982				
	Predacious	9	13	42	2-4012	2-8329				
	Parasitic	10	21	63	2.8910	2.5037				

the gradient of different protection years (table 7).

Table 6 Variations of various insect groups of insect community with

Table 7 shows that the  $\beta$  diversity indices of plant and insect community in the stands which were protected for 11 years is higher than that in other stands along with the gradient variation of protection years. This indicates that the variation of composition structure of insect community is the most obvious and  $\beta$  diversity indices of plant community tend to increase in that stage of protection. Analyzing the variation status of various type stands can find that along with the prolongation of protection time,  $\beta$  diversity indices of plant community don't increase obviously but those of insect community increase greatly in the stands of shorter protection time, and that the  $\beta$  diversity indices increase in plant community but they tend to decrease year by year in insect community in the middle and long protection stands. This can further indicate that insect community had restored obviously in the early protection period and the most variation of it is in 10 years of protection, the restoration of plant community need longer protection time.

Table 7	$\beta$ diversity indices of plant and insect communities in
	different protection years

Stand	19	91	19	92	19	93	19	94	19	95	Ave betwe <del>e</del>	rage n stands
No.	Р	I	Р	I	Р	1	Р	I	Р	Ι	Р	I
1	_	_		_		_		_		_	_	_
2	_	_	_				0	2.5	1.0	4.0	1.0	6.5
3	0	<b>3</b> - 0	0	1.5	1.0	3-5	0	4.0	1.0	3.0	2.0	7.0
4	0	3-5	1.0	2-5	0	4.0	1.0	5.0	1.0	6.0	5.5	12.5
5	2.0	5.0	0	4.0	1.0	1.0	0	3.5	2.0	2.5	6.0	8-5
6	1.0	2.5	0	1.5	2.0	2.5	0	1.5	1.0	2-5	6.5	8.0

P-Plant community; I-Insect community

## 3 Conclusions and discussion

The community characteristics of degraded Chinese pine stands by many years of human damage 3.1 were lack of plant species, simple community composition and vertical structure, low biodiversity index. It

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was found that bush plants were affected mostly. And the numbers of family and species of insect community decreased. biodiversity reduced. The insect group of natural enemy decreased most significantly. The dormant species of phytophagous insects turned to be obvious. And the whole community was rather unstable.

**3.2** The restoration pattern of community diversity which was under human protection was slow restoration of plant community. In early restoration, individual number increase dominated the restoration. Along with the prolonging of protected years, the composition of plant family and species changed a lot, and their numbers continued to increase. Insect community was found sensitive to environment. In the early protection period, insect species obviously increased. In the middle period, the whole community changed significantly, especially the restoration of natural enemy insect group.

3.3 For the restoration of natural Chinese pine stands in north China. 10th year of protection was critical. After 20 years of protection, the stands were restored similar to the normal stands. In the forest management, attentions should be given to the protection of the whole community, in order to accelerate the restoration of biodiversity of the community and make it relatively stable.

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