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Impacts of land cover change on plant and bird species diversity in Hainan Island, China*

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Abstract—Hainan Island, located at the southern end of China, has less than 0.4% of land area but contains 13% of plant and animal species in China. During the last four decades many primary forests have been converted to shrub land, grassland, and tree planation (e.g., eucalyptus forest). As a result, area of primary tropical forest has been reduced from 25.8% in the 1950s to 4% in the 1990s. To assess impacts of land conversion on plant and bird species diversity, a series of samples in primary forest and four types of converted lands were took. The land conversion had tremendously reduced both plant and bird species diversity. Specifically, plant species richness per site was 83.7 in primary forest, 28.3 in shrub land, 12.5 in grassland, 14.4 in eucalyptus forest, and 21.4 in Acacia forest. Bird species richness showed a similar trend: 22.0 in primary forest, 14.5 in shrub land, 2.5 in grassland, 4.9 in eucalyptus forest, and 9.0 in Acacia forest. The Shannon species diversity indices for plants in the five types of land cover were 3.69, 1.99, 0.97, 1.47 and 2.07, respectively. Similarly, the Shannon indices for bird species diversity were the highest in primary forest, and lowest in grassland, and intermediate in shrub land and eucalyptus forest.

Keywords: land cover change, species diversity, Hainan Island.

1 Introduction

Land cover change has an increasing impact on forest ecosystems worldwide. The destruction of native habitats is recognized as one of the greatest threats to biological diversity (McNeeley, 1990; Pearson, 1994; Pulliam, 1992; Vitousek, 1997; Stuart, 1997).

Hainan Island, located at the southern end of China, is the largest tropical area of China. It contains different kinds of tropical forest ecosystems, such as lowland rain forest, mountainous rain forest, mountainous evergreen forest, tropical coniferous forest, and monsoon rain forest. The island has 13% of species of China, or 1% of the world. According to the investigations in the 1950s, more than 4200 vascular plant species were recorded (Zhong, 1983; Wu, 1994). Of which, around 600 species were found in Hainan only (Zhong, 1983; 1991). The tropical rain forests provide a favorable habitat for wild animals. More than 500 species of terrestrial vertebrate animals were reported, among them there were 344 bird species (Ma, 1987).

During the last four decades, Hainan has experienced extensive and rapid deforestation due to logging and land transformation to agricultural use and rubber plantation. Primary forest habitats are being destroyed in the process of logging and transformation to agriculture land use and artificial forests with intensive management. The coverage of primary rain forests was 25.7% in 1956, and it was reduced to 18.1% in 1964 (Guangzhou Geography Institute, 1984), and to 7.8% in 1987. Only about 4% of the primary forests are left at present (Xie, 1991). As tropic forest disappearing and land cover changes, the animals lost their habitats. The populations of many animals have been declined to the endangered level and have been listed in China National red book. In this paper, the impact of land transformation on plants and birds was assessed based on the sampling in five typical forest covers.

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2 Methods

2.1 Sampling methods

In this study, we sampled 24 plots in five land cover types. Among them, six plots were sampled in primary tropical forests, three in shrubs (the succession stage after clear-cutting), three in grassland (after repeat clear-cuts every 1—5 years or shifting agriculture), eight in eucalyptus forests and four in Acacia forests. Eucalyptus and Acacia forests are pulp forests under intensive management and with harvest rotations of 6—10 year.

2.2 Plant species survey

Each sampling plot was 1035 (35×30) m^2 for primary forest, 500 m^2 (25×20m) for eucalyptus and Acacia forests, 25 m^2 (5×5) for shrubs, and 1 m^2 (1×1) for grasslands. Plants with height > 1.5 meters were identified to species. The understory plant species were sampled in five 1×1 quadrates within a large sampling plot in forests and shrubs. Three plots were sampled in each shrub site.

2.3 Bird species survey

The bird species and their numbers were surveyed along a route of 2000 meters long and 20 meters wide at each site for plant species survey across land cover types.

2.4 Calculation for species diversity and richness

The plant species diversity for each plot was computed using Shannon's diversity index. Species richness was expressed by the number of species in each plot. Statistics analyses were done by SYSTAT.

3 Results

3.1 Species richness and diversity

The plant species richness was significantly different ($p < 0.001$) in five land covers (Table 1). In primary forests, the average species richness was 83.7 (Fig.1) and species diversity was 3.69 (Fig.2). In shrubs, the species richness was 28.3 and species diversity was 1.98. In eucalyptus and Acacia forests, the richness was 14.4 and 21.4, and diversity was 1.47 and 2.07, respectively, which were much lower than the richness in primary forests and a little higher than that in grassland (the shifting agricultural land).

Table 1 Matrix of comparison possibility of richness and diversity with bird and plant

	Land cover types	Acacia forest	Eucalyptus forest	Grassland	Shrubs	Tropical forest
Bird richness	Acacia forests	1.000				
	Eucalyptus forest	0.465	1.000			
	Grassland	0.158	0.076	1.000		
	Shrubs	0.047	0.021	0.009	1.000	
	Tropical forest	0.000	0.000	0.000	0.000	1.000
Plant richness	Acacia forests	1.000				
	Eucalyptus forest	0.694	1.000			
	Grassland	0.026	0.662	1.000		
	Shrubs	0.432	0.047	0.044	1.000	
	Tropical forest	0.000	0.000	0.000	0.000	1.000
Bird diversity	Acacia forests	1.000				
	Eucalyptus forest	0.576	1.000			
	Grassland	0.152	0.647	1.000		
	Shrubs	0.656	0.063	0.016	1.000	
	Tropical forest	0.053	0.000	0.000	0.724	1.000
Plant diversity	Acacia forests	1.000				
	Eucalyptus forest	0.196	1.000			
	Grassland	0.045	0.485	1.000		
	Shrubs	0.082	0.049	0.002	1.000	
	Tropical forest	0.000	0.000	0.000	0.000	1.000

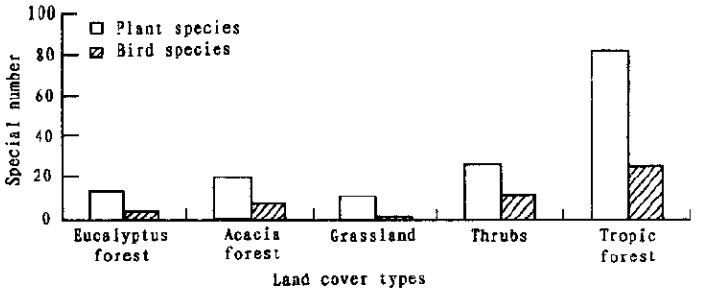

Fig. 1 Species richness in different land covers

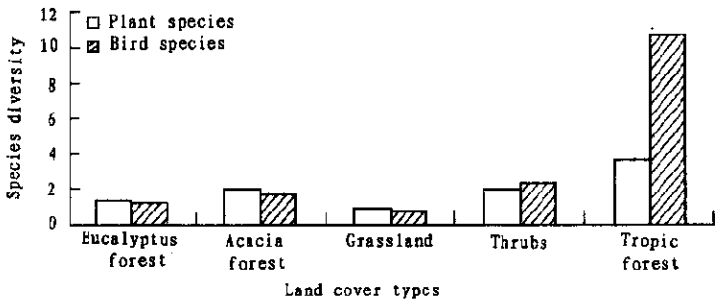

Fig. 2 Species diversity in different land covers

Similarly, the bird species richness in primary forests and shrubs was much higher than that in eucalyptus and Acacia forests. The bird richness and species diversity was 28 and 2.57. In eucalyptus and Acacia forests, the bird richness was 4.9 and 9.0, and diversity was 1.32 and 1.80 respectively (Fig. 1 and Fig. 2).

3.2 Species composition change

Land cover transformation also changed species composition. There was very little common plant and bird species among five land cover types (Table 2).

Table 2 Similarity in five land covers on bird and plant species

	Land cover types	Acacia forest	Eucalyptus forest	Grassland	Shrubs	Tropical forest
Bird species	Acacia forests	1				
	Eucalyptus forest	0.053	1			
	Grassland	0	0.083	1		
	Shrubs	0.069	0.071	0.045	1.000	
	Tropical forest	0.031	0	0	0.073	1.000
Plant species	Acacia forests	1				
	Eucalyptus forest	0.133	1			
	Grassland	0.027	0.200	1		
	Shrubs	0.075	0.103	0.042	1.000	
	Tropical forest	0.027	0.02	0.009	0.066	1.000

3.3 Impacts of eucalyptus forest regeneration on plant and bird diversity

The sampled eucalyptus forests were classified in two groups. The continuously cultivated eucalyptus forests were planted in 1984—1985, and logged and regenerated in 1991—1992 by stump germination. The non-regeneration eucalyptus forests were planted in 1991—1992, and have not been harvested. The results suggested that plant and bird species richness and diversity in regenerated forests were significantly lower than non-regenerated eucalyptus forests (Table 3).

Table 3 Impacts of pulp forest regeneration on plant and bird diversity

	Birds		Plants	
	Richness	Diversity	Richness	Diversity
Regenerated eucalyptus forests	3.5	1.11	12	1.01
Non-regenerated eucalyptus forests	7	1.32	22	1.91
P-value	0.020	0.087	0.035	0.098

4 Discussion

Our study suggested that land cover changes had tremendously reduced plant and bird diversity. Among the five land cover types, primary forests had the highest plant and bird species diversity, followed by shrubs. In eucalyptus forest, a kind of pulp forest, both species richness and diversity of plants and birds were the lowest.

The species richness and diversity decreased remarkably after logging and regeneration. Under multiple harvests and continuos cultivation, the eucalyptus and Acacia forests have a much lower plant and bird diversity.

Transforming primary forests and shrubs to commercial forest will destroy habitat for some plants and birds. The land use change is the main driving forces for species biodiversity loss in Hainan.

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