ACCELERATING REHABILITATION OF NATIVE FOREST BY ESTABLISHING A SEEDLING PRODUCTION SITE IN SOUTH CHINA

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ABSTRACT

Due to long term and frequent human disturbances, the original forest of South China has been almost cleared. Natural forest succession and rehabilitation have been retarded. In the past decade, efforts have been made to rehabilitate forest on degraded hills in South China, which has notably increased regional forest coverage. However, most of the current plantations consist of a few exotic, fast growing trees. They support low biodiversity and weak ecological function. Rehabilitation of native forest, or plantations consisting of native trees can enhance restoration and development of local flora and fauna. This paper reports the floristic diversity in four major forest types, e.g. *Pinus massoniana* plantation, *Pinus elliottii* plantation, *Paraserianthes falcataria* plantation and secondary forest, of Zengcheng City, South China. A project to produce seedlings of native species is described. This project aims to provide seedlings of native trees to accelerate the reintroduction of native species in plantations in South China.

Key words: South China, seedling production, restoration of native forest

INTRODUCTION

Guangdong is a fast growing area in South China. With dramatic progress in industrial, urban and suburban development in the past two decades, have come serious environmental problems. The Guangdong Provincial Government has paid great attention to replanting trees on degraded hills to improve the local environment in the past decade. Provincial forest cover increased from 26.7% in 1985 to 48.9% in 1990. However, most of the plantations consist of few species of conifers or fast-growing exotics, which produce dry fruits that are not eaten by local wildlife. In 1997, the Government proposed that 30% of the total forest area would be used or planted for conservation purposes. The importance of native forest for wildlife conservation is gradually becoming understood. However, utilisation of native tree species in plantations is limited by local shortages of planting stock and by a lack of knowledge of appropriate techniques to use to replant native species.

Floristic diversity plays an important role in biological conservation and soil nutrient cycling. Understanding the development of the plantation understories is necessary to guide plantation management (YU *ET AL.*, 1999). Zengcheng is one of the national demonstration cities in China. Major forest types are secondary forest and plantations. Secondary forests are mainly distributed in the north and have been protected since 1983. Main plantation

species include *Pinus massoniana*, *P. elliottii*, *Paraserianthes falcataria*, *Eucalyptus urophylla*, and *Acacia mangium*. This study investigated the floristic diversity of native forest and various plantations in Zengcheng. Based on this study, a project to produce seedlings of native species will be conducted to provide seedlings of native plants to accelerate forest restoration in South China.

METHODS

Study site

Zengcheng (23° 5'- 23°37' N, 113°29'- 114°E) is a suburb of Guangzhou City in Guangdong Province. It has a south sub-tropical monsoonal climate. The mean annual temperature is 21.6°C and the mean annual rainfall is 1921.6mm. The hottest month is July with a mean temperature of 29°C, whilst the coolest month is January with a mean temperature of 13°C. The rainy season lasts from April to September. The wettest months are May and June when mean monthly rainfall exceeds 300 mm. The dry season, when mean monthly rainfall falls below 100 mm, lasts from October to March. The vegetation zone is south sub-tropical evergreen monsoon forest.

Field survey

Fifteen plots (each $4\times100m^2$) were set up in four forest communities: *Pinus massoniana* (Pm) plantations, *P. elliottii* (Pe) plantations, *Paraserianthes falcataria* (Pf) plantations and native forest, from November 1998 to April 1999 (Table 1). In each plot, trees with diameters at breast height (*dbh*) >2cm were measured and identified.

Table 1 Brief description of the study sites

Plot No.	Forest Type	Age (year)	Location	Altitude (m)	Slope (°)	Aspect
1	Secondary forest	<20	Site 1	670	20°	S
2	Secondary forest	<20	Site 1	570	42°	SE
3	Secondary forest	<20	Site 1	560	36°	N
4	Secondary forest	<20	Site 1	390	35°	N
5	Secondary forest	<20	Site 1	440	50°	NW
6	Secondary forest	>50	Site 1	620	35°	SE
7	Secondary forest	>50	Site 1	740	26°	NW
8	Pf Plantation	8	Site 2	100	25°	NE
9	Pf Plantation	8	Site 2	100	25°	NE
10	Pm Plantation	24	Site 2	90	10°	N
11	Pm Plantation	24	Site 2	90	10°	N
12	Pm Plantation	20	Site 1	310	31°	S
13	Pm Plantation	20	Site 1	310	22°	N
14	Pe Plantation	9	Site 2	50	30°	NE
15	Pe Plantation	9	Site 2	50	30°	NE

Ordination of the plots

The density data matrix of species and plots was analysed by Detrended Correspondence Analysis (DCA) (HILL & GAUCH, 1980) and Single Linkage Clustering (LAMBERT & WILLIAMS, 1962).

Calculation of the indices of Diversity and Evenness

The Shannon function: H = SUM Pi ln Pi, where Pi is the relative proportional abundance of species i and evenness index E = H / ln S (where S is the number of species with dbh greater than 2 cm) were used to describe the communities.

RESULTS

Ordination of the stands and species

A total of 164 tree species (>2 cm dbh), belonging to 50 families and 97 genera, were recorded in the 15 plots, including two nationally protected species, *Artocarpus hypargyrea* and *Amentotaxus argotaenia.* The result of the DCA ordination showed that native forests were separated from those of plantation plots in the first DCA axis due to a negative relationship with altitude ($r^2 = 0.633$, $p<0.001$). In general, native forests are distributed at higher altitude and have low values between 0 and 2.33, while the plantation plots are usually at low altitude and had relatively high values between 2.44 and 5.07. Two plots of *Pinus elliottii* plantations (Nos. 14 & 15) were grouped together, but no clear isolation was found between *Pinus massoniana* plantations and *Paraserianthes falcataria* plantations. Plot 4 of the native forest was close to plots 14 and 15 of *Pinus elliottii* plantations in the first DCA axis.

Classification of the 15 plots

A clustering dendrogram showed that the study plots could be roughly clustered into 4 groups: *Pinus elliottii* (Pe) plantations, *Pinus massoniana* (Pm) plantations, *Paraserianthes falcataria* (Pf) plantations and native forest. However, one of the plantations of *Pinus massoniana* (Plot 13) is clustered with the group of native forest plots.

The two-way table (Appendix 1) showed that the abundance of the major components in different types of forest communities was different. Many of the species were only confined to native forests, including two nationally protected species and several species in the families Fagaceae, Magnoliaceae, and Theaceae which have large seeds.

By comparison, species present in plantations were usually light-demanding or widespread shrubs and small trees, e.g. *Rhodomyrtus tomentosa, Sapium discolor, Litsea cubeba, Ficus variolosa, Glochidion puberum, Rhaphiolepis indica,* and *Itea chinensis.* Many of these species are usually easily dispersed by birds or by wind. Of these, *Schefflera*

octophylla and *Sapium discolor* are the favourite food of frugivorous birds in winter (CORLETT, 1992). The seeds of *Itea chinensis* are small and well dispersed by wind

Major characteristics of the four forest communities

In general, the native forests had higher species richness, higher species diversity and evenness than the plantations (Table 2). Of the plantations, *Paraserianthes falcataria* plantations were the youngest. They not only had the highest basal areas but also had relatively high floristic diversities. *Pinus elliottii* plantations had the lowest diversity (Table 2).

Table 2 Floristic characteristics of the four forest communities. The value in brackets is standard deviation. Pf=*Paraserianthes falcataria*; Pm=*Pinus massoniana*; Pe=*Pinus elliottii*.

Forest type	Species richness	Density (per ha)	Basal area (cm^2/ha)	Diversity H	Evenness E
Native forest	35 (7)	3 182 (1244)	23.25 (3.88)	3.07 (0.27)	0.86 (0.04)
Pf plantation	19 (4)	3 763 (1220)	24.21 (0.10)	2.17 (0.30)	0.74 (0.04)
Pm plantation	18 (2)	2 857 (571)	17.25 (11.42)	2.16 (0.12)	0.74 (0.05)
Pe plantation	19 (1)	3 300 (813)	11.38 (2.76)	1.76 (0.06)	0.60 (0.04)

DISCUSSION

Biodiversity of native forest and plantations

Many studies elsewhere have demonstrated that plantations can catalyse the rehabilitation of native flora on degraded tropical lands, but that the effect varies with the species selected for planting, management practice and site conditions (PARROTTA *ET AL.*, 1997; LUGO, 1997; ZHUANG, 1997). Our study showed that *Paraserianthes falcataria* plantations have a greater beneficial effect, both on production and biodiversity, than the coniferous plantations of *Pinus massoniana* and *Pinus elliottii*. The floristic diversities of the plantations are also influenced by seed source availability. It was observed that two plots (nos. 12 & 13) in *Pinus massoniana* plantations were closer to native forest and had more regenerating native trees than those plots (nos. 10 & 11) in site 2, where there was no well- developed native forest. Therefore, the low diversity of the plots in site 2 was possibly due to restricted seed sources. Our study also showed that the floristic composition of the forest communities varied with altitude. One of the reasons for this was because the temperature and moisture of the microhabitats varies with the altitude. The second and more important reason in the present study was because most native forest is confined to higher altitudes, while most secondary forests in the lowlands have been cleared or frequently disturbed by human activities. Therefore, replanting of native species is necessary to facilitate rehabilitation of native forests in the lowland area.

The diversity of native forest is obviously higher than that of plantations. They are precious natural resources and biological heritage and we should protect them. However, the native forests in Zengcheng are mainly dominated by light-demanding species. Many dominant trees in intact forest, such as species in the families Fagaceae and Magnoliaceae, are rare. These species are usually vulnerable to change in habitats because they are poorly dispersed and grow slowly. The seeds of several *Castanopsis* spp. (Fagaceae), such as *C. lamontii, C. eyrei, C. carlessii* and *C. fabri* are collected from the trees before falling or from the forest floor by local residents. These human activities will decrease the seed population of these species *in situ* and thus affect their regeneration. Planting of these species in ecological plantations can both propagate their population and also provide food for human beings.

Potential utilisation and limitations of native flora in plantations

The importance of native forest to wildlife conservation is gradually becoming understood. Native tree and shrub species have been increasingly required in garden planting and ecological plantations, but they are not able to be widely applied because planting stock of most native species is not available in the local market and information about native plants are generally lacking. It was found in some local nurseries that the seeds and seedlings of many native species could germinate and grow well. However, it is difficult to obtain seed because there are only a few seed and seedling markets of native woody species. In addition, the prices of native species are generally much higher than those of common plantation species like *Eucalyptus* and *Acacia*. Another major limitation is that the growth of many native species is not as fast as that of exotic species. Therefore, screening species for fast growth and high economic and ecological values and decreasing costs of production are key issues for the utilisation of native species in plantations.

Research on seedling production of native species of South China

The project for production of suitable tree species was initially supported by the Forestry Department of Guangdong Province from 1998 and will be supported by Kadoorie Farm and Botanic Garden between 2000-2002.

The main purpose of this project is to establish a production nursery for native tree seedlings that are suitable for reforestation and urban planting in South China including Hong Kong. The second purpose is to set up an arboretum with native tree species that have high utilisation potential in South China. Both the nursery and arboretum will also serve as research sites for the study of native plants. The long-term objective is to accelerate the natural process of forest succession on degraded lands in South China. In 2002, the Nursery aims to produce 200,000 seedlings of 60 native species.

The project started last year when seeds of 54 native tree and shrub species in 30 families and 44 genera (Appendix 2) from local secondary forest were collected and sown in the nursery. More than 70% of species produce fresh fruits/seeds which can provide food for birds or mammals. Some species such as *Acer cinnamomifolium, Rhodoleia championii*, and *Tutcheria championii* can also potentially be used for ornamental or urban planting. For

each species, mean size and weight of the fruit/seed were measured and recorded. Seeds were sterilised with a 0.5% $KMnO_4$ solution for 30 minutes and soaked in water for 1 day before sowing in seedling beds containing sandy soil. No special treatments were conducted to stimulate seed germination except for a few species with a hard and thick seed/fruit coat, which were soaked in hot water before sowing. To date, approximately 20 species have germinated successfully in the greenhouse (Appendix 2).

The use of stem cuttings is also an important approach for seedling production and is especially necessary for species with low seed production or low seed germination rates. An experiment on stem cuttings was done on a few shrub species such as *Ficus hirta, Melastoma sanguinea, M. candidum, Rhodomyrtus tomentosa, Ilex asprella* last year. The preliminary results show that many of these species could produce new roots and shoots from cuttings, but the survival rates vary with the season and are usually low in summer. Cutting trials will be continued on other species this year.

The first batch of 10 native species, including species of the families Magnolicaeae and Fagaceae will be planted in the demonstration site in March this year. At least 30 native species will be planted for demonstration before 2003. Monitoring of survival and growth of planted seedlings will be conducted soon after planting.

CONCLUSION

Native forests have richer diversity than plantations, but most of the existing secondary forests in Zengcheng are dominated by light-demanding pioneer species. Plantations can catalyse the rehabilitation of native flora, but the effects vary with the species chosen for planting, altitude and distances from intact forests that produce seed. *Paraserianthes* plantations are better than coniferous plantations for both growth and floristic diversity.

Planting native species can accelerate recolonisation of degraded forest sites by native flora and fauna. Major limitations for the use of native species are lack of planting material of most native species in local markets and shortage of information about propagating native trees. Our project to produce seedlings of native species aims to accelerate rehabilitation of native forests in South China by providing suitable seedlings for both plantations and urban planting.

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QUESTIONS AND COMMENTS

Yadi Setiadi.

What measures have been taken to prevent attack by pest insects on this species, which we have had in Indonesia?

Zhuang Xueying

I know that there have been such problems in our urban plantings, but not in these plots which are less than 30 years old. However, I would be concerned about pest problems with all exotic species.

John Parrotta

The forest fragments – how well protected are they? Do you have the support of the forestry bureau and local people in the province? This would be good for you to promote larger scale production in the future.

Zhuang Xueying

The forest fragments are currently protected – cutting is forbidden by a policy introduced last year. Plantations are separate. They can be cut, but only for conservation purposes. Usually in private plantations, they are harvested after about 5-6 years, which can cause problems to have such short rotations, but now they are starting to protect the understorey and to encourage other vegetation to grow. This project is supported by the local government and also by the farmers.

Appendix 1 Two-way table of clustering analysis for the 15 plots on density data.

Forest Type	Plot No Species	14	15	8	9	10	11	12	13	4	1	2	3	5	6	7
Pm	*Adina pilulifera*	1	4		2	8	7			1						
	Rhodomyrtus tomentosa					10	4	4	2	2						
	Pinus massoniana					40	47	37	9	1						
	Zanthoxylum avicennae		1			1	3			4						
	Melastoma candidum						1	1	1							
	Camptotheca acuminata							6	4							
Pe	*Sapium discolor*	1	1	8	8	1	2	1	4	1						
	Litsea rotundifolia	2	1		1			1	3		2	1				
	Rhus chinensis	30	17	2												
	Ilex asprella	8	2			1										
	Phyllanthus emblica	4	3													
	Pinus elliottii	82	58													
	Eurya ciliata	2		1												
	Liquidambar formosana	4	1													
Pf	*Glochidion puberum*	9	5	1	20	13	2		1							
	Aporosa dioica	1	1		3	3	1									
	Litsea cubeba			3	18	4	7									
	Rhus succedanea	1			8	1	2									
	Cratoxylon cochinchinense	1	4		2											
	Microcos paniculata		3		1	1										
	Evodia lepta				38	6	7		1							
	Paraserianthes falcataria			15	45											
Native	*Ficus variolosa*		2		1	3	14	1	1		20	13	3	9	3	8
forest	*Diospyros morrisiana*				11			5	5	1	6	5	4	4		
	Syzygium buxifolium									6	6	7	2	6	7	2
	Castanopsis fissa		2					1			1	1		1		1
	Schefflera octophylla	1		1	3	7	5			20				3		
	Randia cochinchinensis			1							5	10	2	6		6
	Rhaphiolepis indica		1			5					1	7	4			7
	Cinnamomum parthenoxylon	1			2									3	2	1
	Helicia reticulata							1		2	2			2	4	
	Rapanea neriifolia								3	2	22	33		11	2	5
	Lithocarpus harlandii										10	9	5	2	12	
	Engelhardtia fengelii											2	3	2		1
	Symplocos lancifolia										2	3			1	1
	Itea chinensis				7	5	1	1	57	1	14	2		1		
	Machilus chekiangensis									4	1				2	1
	Machilus velutina									1		1	4	2		
	Machilus breviflora										11	1	1	8		2
	Altingia chinensis											8	4		2	1
	Illicium dunnianum											1		1	1	
	Euyra nitida											14	2	11		2
	Ormosia semicastrata								12		7	1				2
	Elaeocarpus chinensis										2			1	1	
	Litsea verticillata										2		1	1		
	Pentaphylax euryoides							1						2	1	
	Lithocarpus glaber													3	1	3
	Homalium cochinchinense											1	3		3	
	Artocarpus hypargyrea											1		3	1	

Forest Type	Plot No Species	14	15	8	9	10	11	12	13	4	1	2	3	5	6	7
Native	*Ilex virdidis*							2	2		11			1		
Forest	*Eurya trichocarpa*									14			1	1	12	
cont.	*Euyra macartneyi*										17	21		2		1
	Reevesia pubescens							1			4		1			
	Beilschmiedia intermedia										5	1			1	
	Beilschmiedia percoriacea													1	1	
	Symplocos lancilimba													1	1	
	Tricalysia dubia											3		4		
	Diospyros kaki									2					3	
	Cinnamomum wilsonii											1			2	
	Ilex formosana												5		13	
	Cryptocarya chinensis													1		20

Note: Only 61 major species are shown. Planted species shown in bold.

Appendix 2 The life form, fruit type, potential dispersal agency, current germination status of the species being studied in the project.

Family	Species	Life form	Fruit type	Dipersal[1]	Treat-ment[2]	Germination[3]
Aceraceae	Acer cinnamomifolium	tree	samara	W		+
Anacardinaceae	Choerospondias axillaris	tree	drupe	M	*	++
Aquifoliaceae	Ilex asprella	shrub	berry	B		-
	Ilex pubescens	shrub	berry	B		++
	Ilex rotunda	tree	berry	B		-
Araliaceae	Aralia chinensis	shrub	berry	B		++
	Schefflera octophylla	tree	drupe	B		++
Caprifoliaceae	Viburnum sempervirens	shrub	berry	B		-
Chloranthaceae	Sarcandra glabra	shrub	berry	B		++
Ebenaceae	Diospyros chunii	tree	berry	B & M		+
	Diospyros morrisiana	tree	berry	B & M		-
	Diospyros tsangii	tree	berry	B & M		++
Euphorbiaceae	Antidesma japonica	shrub	drupe	B		++
	Mallotus apeltus	tree	capsule	B		+
	Sapium discolor	tree	capsule	B		+
Fagaceae	Castanopsis eyrei	tree	nut	unknown	*	-
	Castanopsis fabri	tree	nut	unknown	*	-
	Castanopsis fissa	tree	nut	unknown	*	++
	Cyclobalanopsis flueryi	tree	nut	unknown	*	+
	Cyclobalanopsis hui	tree	nut	unknown	*	-
	Lithocarpus glaber	tree	nut	unknown	*	-
Hamamelidaceae	Altingia chinensis	tree	capsule	W		++
	Liquidambar formosana	tree	capsule	W		++
	Rhodoleia championii	tree	capsule	W		+
Hyperiaceae	Cratoxylum cochinchinense	tree	capsule	W		+
Lauraceae	Litsea rotundifolia	shrub	drupe	B		+
	Phoebe shearei	tree	drupe	B		++
Magnoliaceae	Tsoongiodendron odorum	tree	follicle	B		+
Melastomataceae	Melastoma candidum	shrub	capsule	B		++
	Melastoma sanguineum	shrub	capsule	B		+
Moraceae	Ficus hirta	shrub	fig	B & M		++
Myrsinaceae	Ardisia crenata	shrub	berry	B		++
Myrtaceae	Rhodmyrtus tomentosa	shrub	berry	B		++
	Syzygium buxifolium	shrub	drupe	B		++

Family	Species	Life form	Fruit type	Dipersal[1]	Treat-ment[2]	Germination[3]
Papilionaceae	Ormosia semicastrata	tree	legume	B	*	+
Pittosporaceae	Pittosporum glabratum	shrub	capsule	B		-
Podocarpaceae	Podocarpus flueryi	tree	drupe-like	M	*	+
Rhamnaceae	Hovenia dulcis	tree	drupe	B & M		-
Rosaceae	Pyrus calleyriana	tree	pome	B		++
	Rhaphiolepis indica	shrub	pome	B		++
Rubiaceae	Gardenia jasminoides	shrub	berry	B & M		+
	Psychotria rubra	shrub	berry	B		++
	Tricalysia dubia	tree	berry	B		-
Rutaceae	Evodia lepta	shrub	capsule	B		-
	Evodia meliaefolia	tree	capsule	B		-
Staphyleaceae	Euscaphis japonica	tree	capsule	B		-
	Turpinia arguta	shrub	drupe	B		-
Styraceae	Rehderodendron kwangungensis	tree	dry fruit	unknown		-
Theaceae	Eurya chinensis	shrub	berry	B		++
	Tutcheria championii	tree	capsule	unknown		++
	Tutcheria microcarpa	tree	capsule	unknown		++
Tiliaceae	Microcos paniculata	tree	drupe	B		-
Ulmaceae	Trema cannabina	shrub	drupe	B		-
Verbenaceae	Callicarpa pedunculata	shrub	drupe	B		-

Notes: [1]Agency of dispersal: B=bird, M=mammal, W=wind;
[2]Treatment: *=soaked in hot water before sown;
[3]Germination status: ++ = well germinated, + = poor germinated, - = not germinated.