CHARACTERISTICS AND ROLE OF *ACACIA AURICULIFORMIS* ON VEGETATION RESTORATION IN LOWER SUBTROPICS OF CHINA

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PENG, S. L., LIU, J. & LU, H. F. 2005. Characteristics and role of *Acacia auriculiformis* on vegetation restoration in lower subtropics of China. *Acacia auriculiformis* was introduced to degraded lower subtropical China for vegetation restoration. A long-term case study showed that these trees grew fast and formed forest cover in the degraded land. The leaf area, efficiency of solar radiation utilization, biomass as well as productivity of the forests reached a high level and the soil fertility was improved through nitrogen fixation of tree roots. *Acacia auriculiformis* communities reconstructed the habitat in degraded areas, which provided appropriate settlement conditions for native species and the whole community was in advanced succession. However, with the development of community structure, *A. auriculiformis* showed indication of decline gradually due to the changing environment and unsuccessful self-regeneration. They would be replaced increasingly by native species which adapt to the changed habitat. As exotic species, *A. auriculiformis* was demonstrated to be a safe and ideal tree for vegetation restoration in degraded lower subtropics. However, it can be considered only as pioneer species and some forest reconstruction measures should be taken to accelerate the process of restoration.

Key words: Exotic species – pioneer species – man-made forest – nitrogen fixation – eco-security – South China

PENG, S. L, LIU, J. & LU, H. F. 2005. Ciri-ciri dan peranan *Acacia auriculiformis* dalam pemulihan tumbuhan di kawasan subtropika rendah negara China. *Acacia auriculiformis* diperkenalkan di kawasan subtropika rendah negara China yang tercurai untuk tujuan pemulihan tumbuhan. Kajian jangka panjang menunjukkan bahawa pokok ini tumbuh cepat dan membentuk litupan hutan di tanah tercurai. Luas daun, kecekapan penggunaan sinaran suria, biojisim dan daya pengeluaran hutan mencapai tahap yang tinggi. Kesuburan tanih juga diperbaik melalui pengikatan nitrogen oleh akar pokok. Komuniti *A. auriculiformis* membina semula habitat di kawasan tercurai lalu menyediakan keadaan penempatan yang sesuai untuk spesies asli. Keseluruhan komuniti berada dalam sasaran yang lanjut. Namun, dengan perkembangan struktur komuniti, *A. auriculiformis* lama-kelamaan menunjukkan kemerosotan disebabkan persekitaran yang berubah-ubah dan pemulihan diri yang tidak berjaya. *Acacia* *auriculiformis* akan semakin digantikan dengan spesies asli yang dapat menyesuaikan diri kepada persekitaran yang terubah. Sebagai spesies eksotik, *A. auriculiformis* terbukti sebagai spesies yang selamat dan unggul dalam pemulihan tumbuhan di kawasan subtropika rendah yang tercurai. Namun, *A. auriculiformis* cuma boleh dianggap sebagai spesies perintis dan langkah-langkah pembinaan semula hutan perlu diambil untuk mempercepat proses pemulihan.

Introduction

Acacia auriculiformis (Fabaceae), a fast-growing tree, is native to Cape York peninsula in Queensland, islands of the Torres Strait, Australia, Indonesia and south-east of Papua New Guinea, which naturally distributes in the southern latitudes from 7–20, under elevation of 500 m. It was introduced to China from South-East Asia in 1961 by the South China Botanical Garden, Chinese Academy of Sciences and was widely accepted since the end of the 1970s because of its resistance to infertile soil and fast growth. It was used not only as a street tree to adorn cities but also as an afforestation tree to conserve water and soil as well as improve soil fertility in the hilly and coastal areas of Hainan, Guangdong, Guangxi and Fujian provinces in China. The area of afforestation is now up to 670 km^2 and if the street trees were lined up, the total length would be close to 3000 km. *Acacia auriculiformis* has become one of the main tree species for water and soil conservation, soil fertility improvement, firewood and mixed forest cultivation. This *Acacia* tree species introduced to China, now, has the broadest plantation area (Xu & Huo 1982, Gao & Ma 1990). It was also introduced to south China for ecosystem restoration in degraded regions of low subtropics. The objective of this study was to understand its characteristics and role in the process of vegetation restoration.

Materials and methods

Study sites

Xiaoliang research station of the Chinese Academy of Sciences (21° 27' N, 110° 54' E) is located in the lower tropics. The mean annual temperature is 22.6 °C varying from 4.7 to 36.5 °C. Mean rainfall is 1400–1700 mm, with dry season lasting more than half a year (Figure 1). On the regional laterite, the vegetation is tropical monsoon forest. However, all that remains today is some secondary forest beside the villages because of human activity. Nearly 100 years' soil erosion has ultimately led to an exceedingly impoverished soil, containing 0.6% of organic and 0.03% of total nitrogen, with poor physical structure and chemical properties.

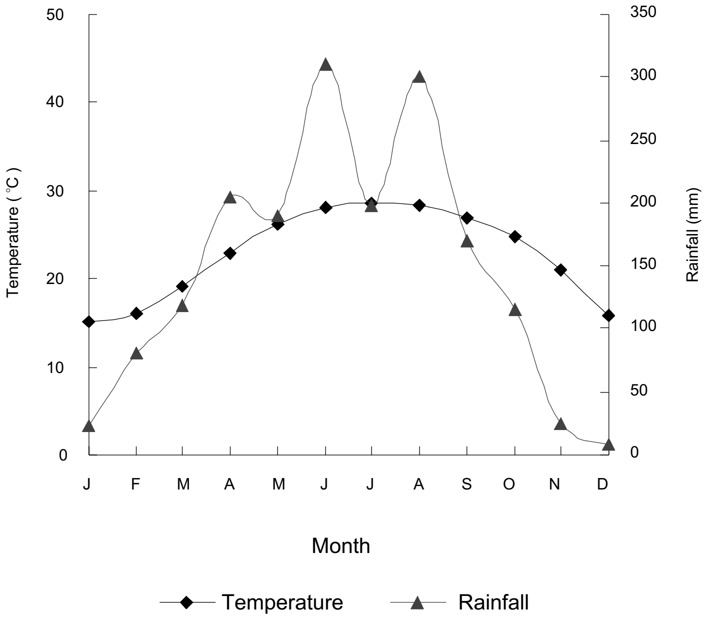

Figure 1 Mean temperature and rainfall in Xiaoliang station (from 1981 till 1995)

The ecosystem is degraded. In order to improve it, vegetation restoration studies have been carried out since 1959. *Acacia auriculiformis* was introduced as the main pioneering species of mixed broad-leaved forests.

Heshan hilly land interdisciplinary experimental station of the Chinese Academy of Sciences (22° 40' N, 112° 50' E) has a total area of about 1.7 km^2. Mean annual temperature is 21.7 °C varying from 0 to 37.5 °C and annual rainfall is about 1801.8 mm (Figure 2). Mean radiation is 435.47 kJ cm^{-2} and cumulative temperature above 10 °C is 7595.2 °C. Typhoons occur several times each year. On the red soil, the climate is low subtropical monsoon evergreen broad-leaved forest. As a result of serious human disturbance, the soil erosion was critical and the original vegetation had almost disappeared. Since 1983, ecosystem restoration study has begun with the aim of establishing an effectively compound agroforestry ecosystem. *Acacia auriculiformis* is one of the main species in the communities in the early stage of succession.

The Xiaoliang and Heshan stations offered satisfactory research platforms for this research. Climatic data were continually being recorded by professionals with the aid of automatic observation apparatus. Both permanent and temporary sites with an area of 30 × 40 m were set up to study the growth change of *A. auriculiformis* trees and dynamics of the forest communities.

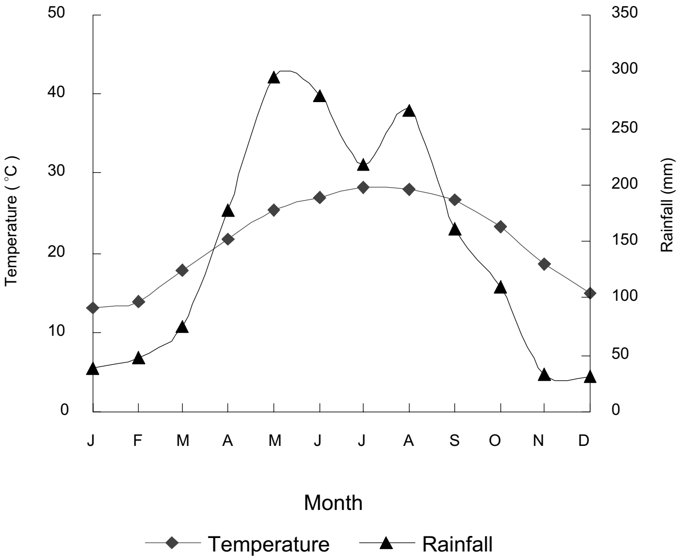

Figure 2 Mean temperature and rainfall in Heshan station (from 1988 till 2000)

Phenological observation

Fixed plots were set up and 10 trees from each plot were selected for observation. The data were recorded on the 10th, 20th and last day of every month. Considerations included the beginning and end of bud bursting, blossoming, flowering and fruiting, leaf shedding periods as well as seasonal aspect of the forest and canopy colour.

Biomass and growth increment

A total of 50 trees were selected at random to measure the total height and diameter at breast height (dbh). The average height and dbh were calculated to select standard trees. The increments of dbh of some standard trees were examined over the years. Others were cut down to examine the fresh weight of trunk, branches, leaves and roots. Each part was sampled and oven dried to examine the dry weight. This enabled the ratio of dry weight to fresh weight of each part to be calculated and the biomass of the whole tree could be obtained in proportion. With this data the relative growing equation of each part of the tree was established to calculate the biomass of the tree at different dbhs. Therefore, the biomass of the whole forest could be calculated with the data of tree density.

Nitrogen fixation

Five trees in each plot were selected and three root nodule samples per tree collected. The nitrogen fixation activity was measured using the acetylene reduction method. It was tested by gas chromatography with hydrogen flame. The chromatography column was filled with active aluminium oxide, 60–80 orifices, coated with Apiezon grease M. The flow rate was 65 ml min^{-1}.

Canopy structure

Leaf inclination was directly measured or calculated using the Warren–Wilson equation. Leaf orientation was measured at the bottom of the canopy through a fish-eye camera. Such methods were also applied to measure branch angle.

Leaf area index

After the standard trees were selected and cut down, the leaves at each height layer were collected and weighed. According to the cross-parting method, 500–1000 g of leaves were selected and measured with an LI-3000 portable area meter. The leaf area index (LAI) of each height level was calculated.

Caloric value

The trunk samples were taken at 1.3 m height. Leaves were divided into old and young, and sampled in proportion. Root material was divided into coarse and fine roots. All these samples were oven dried and milled to powder. With the GR-3500 oxygen-bomb calorimeter, the caloric value was measured.

Physiologic indices

Photosynthesis, respiration and transpiration rate were measured three times each month with a plant assimilation analyser and CO_2 gas analyzer. Observations were carried out every two hours from 6 a.m. till 6 p.m. and the average value was calculated.

Litter collection

Ten collection boxes were set up at 0.5 m height above the ground in each plot. The boxes were made of nylon wire of 1 mm diameter with a volume of 1 m^3. The litter was collected at the end of each month and dried at 80 °C. The weights of leaves, branches and fruits were measured separately.

Soil animal survey

Ten sampling points were selected in each plot. All ground cover at each point within an area of 0.1 m^2 was gathered and tiny soil animals were collected with Tullgren equipment. Five soil cores were sampled randomly with a soil sampler of 8 cm diameter to survey medium and large-scale animals. Three soil layers were separated with soil sampler of 4 × 5 × 5 cm and four soil samples were taken from each layer to survey mesocole with Bawrmann equipment.

Simulation of growth dynamics

Through the measurement of each plant part, the biomass of the tree as well as nitrogen and carbon contents, a storage and flow ideograph could be drawn. With a large quantity of physiological indices and data of environmental factors, the growth dynamics were simulated using the DYSAY program (Bossel 1986, Bossel *et al.* 1989) to predict the development trends of *A. auriculiformis* forest.

Results and discussion

Biological characteristics and biotemperature

Acacia auriculiformis tree has a dense and wide canopy. It can reach up to a height of 30 m and dbh of 60 cm. The branches facing the sun had more than 120 inflorescences, with approximately 14 000 flowers. The rate of fruit production was 0.94%. The branches inside the canopy had 134 inflorescences and 17 000 flowers. Fruit production rate was only 0.34%. This phenomenon, many flowers but few fruits, may be caused by the subvital pollen of stamens, deletion of stilet in pistils and damage by insects. The morphology of trees varied greatly. It can be classified into two types. One has ptosis lateral branches, with a straight trunk and hoary smooth bark, and the included angles of branch intersect with the main trunk are generally beyond 60°. The other is with a sinuous trunk and deep russet, rough and thick bark which has many splits. The arborization of main trunk is cirrate but not high and the included angles of lateral branches intersect with the main trunk are less than 45° (Keogh 1990). *Acacia auriculiformis* has the latter form.

Flower buds began to form in July and bloomed a month later at the Xiaoliang station, which is located in north edge of the tropic zone with zonal vegetation of monsoon forests. *Acacia auriculiformis* can grow all year round in this region. The fruiting period lasted from November till April the following year.

The biotemperature was different when the same species was planted at different places. In Xiaoliang, *A. auriculiformis* can bloom and bear fruit three years after planting. However, at the Leizhou peninsula, about one latitude south to Xiaoliang station, *A. auriculiformis* needs only two years. The flowering period was from August till September and pods matured from April till May next year, while at Leizhou peninsula, it was a month earlier, from July till August, and pods matured from December till January the next year.

Vertical distribution of leaf area index

The structure and function of the *A. auriculiformis* community can be partly expressed by the structure of its leaf area. LAI is an important index indicating the growth state of the plant. *Acacia auriculiformis* had considerable leaf weight and LAI, with a good distribution of LAI (Table 1). This state is favourable for the whole community to improve the efficiency of its photosynthesis and accumulation of organic mater.

Rates of photosynthesis, respiration and transpiration

Two artificial mixed forests were selected to measure and compare their photosynthetic rates, both of which have *A. auriculiformis* as their community established species. Community I was located at the top half of the slope, with seven-year-old *A. auriculiformis*. Community II was located at the bottom, with nine-year-old *A. auriculiformis*. The maximum photosynthesis rates of *A. auriculiformis* were similar, and both of them appeared at 14:00 (Figures 3 and 4). Compared with other species, *A. auriculiformis* had a higher photosynthesis rate. This is favourable for rapid accumulation of organic matter in the communities. Community I had a lower photosynthesis rate compared with community II because of the limited water supply and higher transpiration.

Table 1 The vertical distribution of leaf weight and leaf area index

Height (m)	Weight of leaf (kg m^{-2})	Leaf area index
0–1	0	0
1–2	0.032	0.08
2–3	0.021	0.08
3–4	0.077	0.19
4–5	0.113	0.28
5–6	0.255	0.63
> 6	1.158	2.84
Total	1.656	4.10

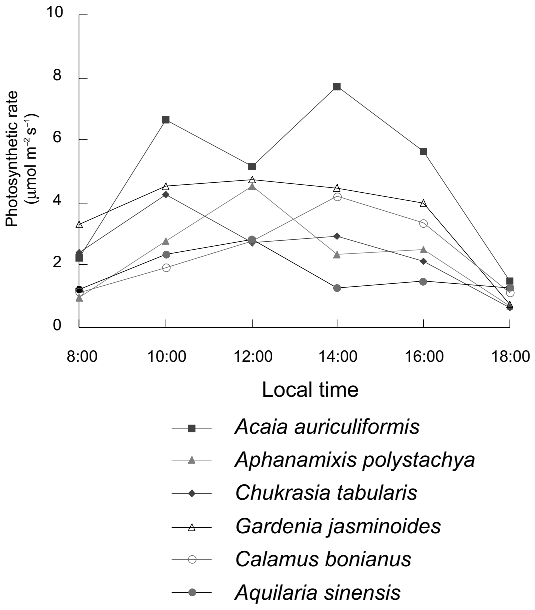

Figure 3 Daily variation of photosynthetic rate in the mixed forest I

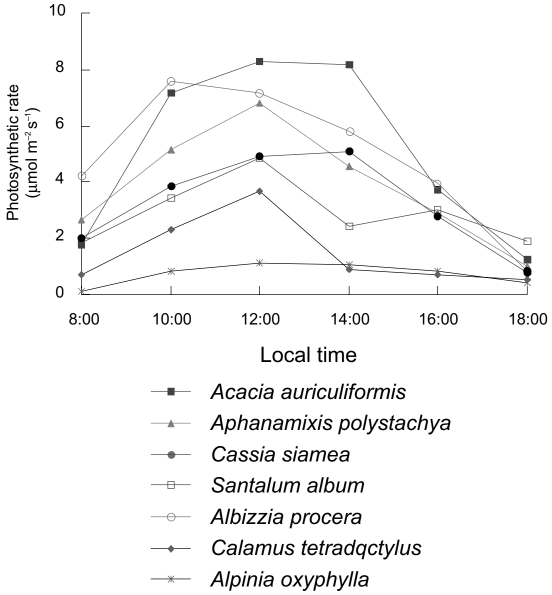

Figure 4 Daily variation of photosynthetic rate in the mixed forest II

The respiration rate of *A. auriculiformis* had a positive correlation with light flux density and the respiration rate had daily and seasonal variations. The rate at noon was higher than those in the morning and night. It was also higher in summer than in winter (Figures 5 and 6). The average rate in January was 0.027 mmol g^{-1} h^{-1}, while in July it was 0.043 mmol g^{-1} h^{-1}.

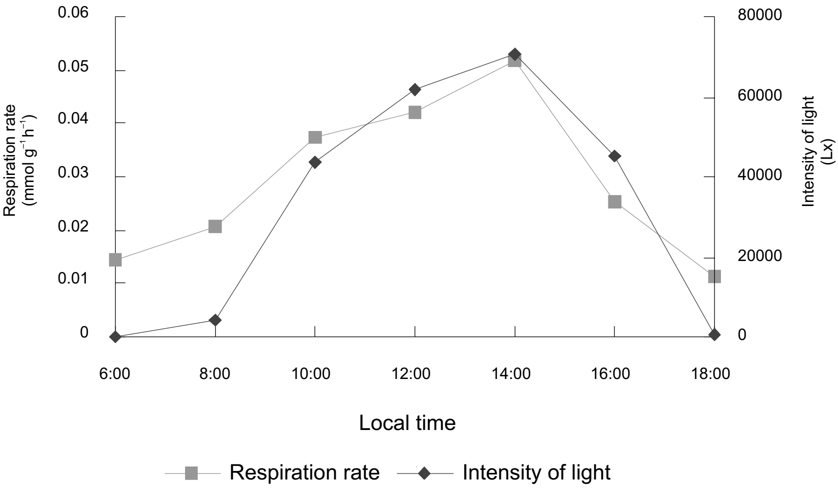

Figure 5 Effect of light intensity on respiration rate of *Acacia auriculiformis* in January

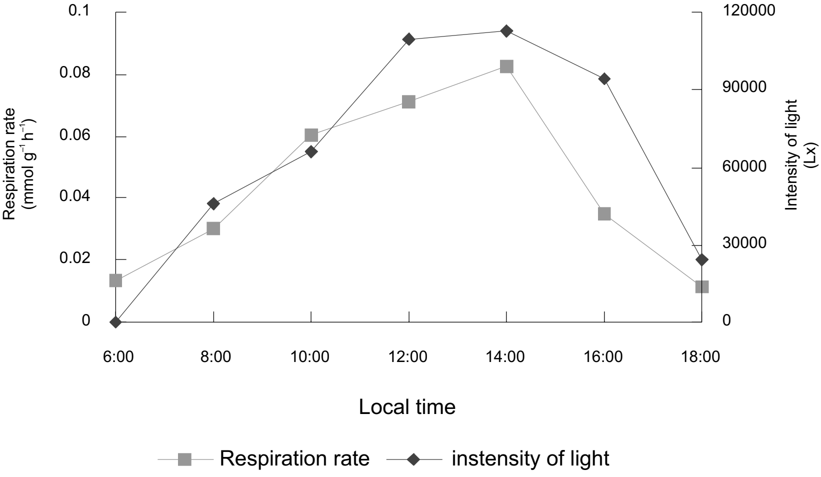

Figure 6 Effect of light intensity on respiration rate of *Acacia auriculiformis* in July

The transpiration rate was low in the morning and evening but higher at noon (Figures 7 and 8). Due to the dry winter and hot summer at Xiaoliang, transpiration was lower in January compared with in July. There was a strong correspondence between transpiration and illumination density. According to our measurement of the artificial forest at Xiaoliang, the transpiration of *A. auriculiformis* was high. The cost for 1 g dry organic matter was only 123.1 g water.

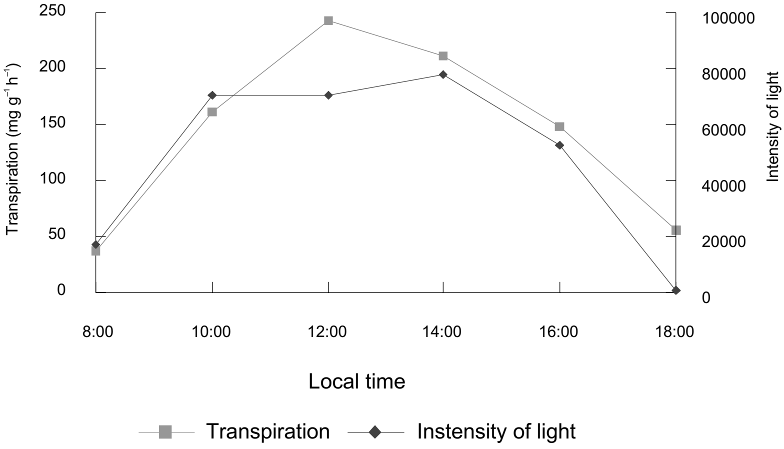

Figure 7 Relationship between transpiration and intensity of light in *Acacia auriculiformis* in January

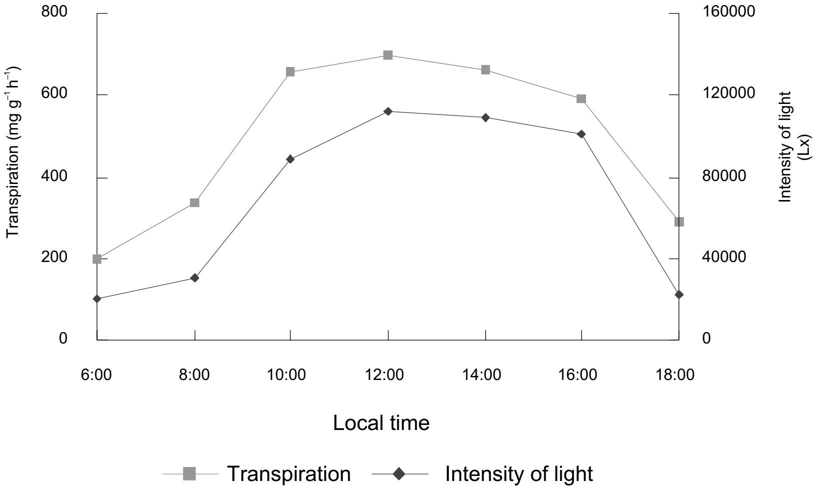

Figure 8 Relationship between transpiration and intensity of light in *Acacia auriculiformis* in July

Community structure

The habitat situation was poor before *A. auriculiformis* was planted. Only *Ischaemum indicum* (Poaceae), *Eriachne pallescens* (Poaceae), *Baeckea frutescene* (Myrtaceae) and a few other heliophyte species could grow. After seven years, the average height of the tree was 9.65 m, average dbh was 7.36 cm and the coverage 70–80%. Forest dominated in the upper layer and brushwood formed in the underlayer, of which the species included *Litsea cubeba, L. rotundifolia* (Lauraceae), *Schima superba* (Theaceae), *Mallotus apelta* (Euphorbiaceae), *Psychotria rubra* (Rubiaceae), *Raphiolepis indica* (Rosaceae), *Ilex asprella* (Aquifoliaceae), *Rhodomyrtus tomentosa* (Myrtaceae), *Dicranopteris pedata* (Gleicheniaceae) and liana of *Mussaenda pubescens* (Rubiaceae). The xerophilous grass retreated gradually. Twenty-one years after planting, the aspect of man-made *A. auriculiformis* forest was dark green, with a regular canopy. The average height of the tree was 21.5 m, dbh 45.8 cm and canopy range 13.8 m^2. Shrub and grass species under the forest were more abundant. Moreover, the autochthon trees, such as *S. superba, Schima wallichii* (Thaeceae), *Castanopsis hystrix* (Fagaceae), *Castanea henryi* (Fagaceae) and *Michelia macclurei* var. *sublanea* (Magnoliaceae) appeared one after another. The community had full canopy density in horizontal distribution, and tree and grass layers in vertical distribution. This suggested that the composition and structure of the community were becoming more and more complex and the whole community was in advanced succession.

Biomass and productivity

Biomass is the energy foundation of ecosystems and it reflects the restoration process. The biomass models of *A. auriculiformis* were set up with a relative growing equation by measuring the average trees (Table 2), with which the productivity of forest was evaluated. The total above-ground biomass of seven-year-old forest was

Table 2 The relative growing equation and the linear regressive equation of biomass for each above-ground part of *Aacacia auriculiformis*

Items	Relative growth equation	Linear regressive equation	Correlation coefficient
Trunk	$W_S=0.044(D^2H)^{1.035}$	$lgW_S=-1.357+1.035lg(D^2H)$	0.99
Leaf	$W_L=0.0064(D^2H)^{1.085}$	$lgW_L=-2.193+1.085lg(D^2H)$	0.91
Branch	$W_B=0.0093(D^2H)^{1.085}$	$lgW_B=-2.031+1.085lg(D^2H)$	0.91
Total above-ground biomass	$W_T=0.0624(D^2H)^{1.043}$	$lgW_T=-1.205+1.403lg(D^2H)$	0.98

9.688 kg m^{-2}, of which 54.85% was in the trunk, 16.24% in the branch and 17.09% in the leaf (Peng *et al.* 1992) However, root biomass accounted for only 11.82% of the total, which indicated that the supporting ability of the root system was relatively weak. The vertical distribution of biomass above ground was reasonable and advantageous for utilizing the spatial resources (Table 3).

The increment of tree biomass above the ground was measured in the fourth, fifth and sixth year after planting, which were 3.216, 1.923 and 0.761 kg m^{-2} respectively (Peng *et al.* 1992). This trend reflected the rate of growth, which reached a peak in the early stages but sharply declined after six years.

Energy distribution and efficiency of solar radiation utilization

The calorific value of each tree part is quite different. The measurement from seven-year-old forests in Heshan station showed that the value of leaf was 20.1518 kJ g^{-1} (at a maximum), that of branch was 17.4372 kJ g^{-1}, trunk was 17.0188 kJ g^{-1} and that of root was 1.8432 kJ g^{-1} (Ren *et al.* 1995). This may be because the leaves contained more high-energy matter such as protein and roots absorbed a lot of nutrients, whereas the trunks supporting the tree body were mainly composed of cellulose.

The whole energy storage of the community, which was calculated through biomass and calorific value was 1.722 × 105 kJ m^{-2}. The accumulation at the trunk was the greatest, which accounted for 52.4%. The leaf had 19.4% while the branch and root had 15.9 and 12.3% respectively.

Form to the observation of litter at the same period, the amounts were 0.35 kg m^{-2} a^{-1} in six-year-old forests and 0.65 kg m^{-2} a^{-1} in seven-year-old forests (Li *et al.* 1990) This litter, with the death of roots, limited continuous energy accumulation in leaf, branch and root, but it provided energy for decomposers, which completed energy transformation and flow in the ecosystem.

Table 3 The vertical distribution of biomass (kg m^{-2})

Height (m)	Trunk	Branch	Leaf	Σ
0–1	1.320	–	–	1.320
1–2	1.032	0.030	0.032	1.094
2–3	0.892	0.020	0.021	0.9.33
3–4	0.707	0.264	0.077	1.048
4–5	0.553	0.195	0.113	0.8.61
5–6	0.481	0.269	0.255	1.005
> 6	0.329	0.795	1.058	2.282
Root	–	–	–	1.145
Total	5.314	1.573	1.656	9.688

The net energy fixation of the community refers to the energy fixed by photosynthesis minus the loss caused by respiration, perish, wither, insect attack, etc. in a unit area and time. The biomass increment values of five-, six- and seven-year-old communities were 3.216, 1.923 and 0.761 kg m^{-2} respectively. The energy stored in the average annual increment of biomass of the seven-year-old community could be evaluated according to the calorific value, which was 1.35×10^4 kJ m^{-2}. This value, plus the loss caused by nitrogen fixation, became the annual net energy fixation of 13.8×10^4 kJ m^{-2}. Since the annual gross solar radiation in Heshan station was 4.7514×10^6 kJ m^{-2} (Ren *et al.* 1995), the efficiency of solar radiation utilization of the community was about 0.32%, which was higher than that of mixed coniferous forests and autochthon forests.

Nitrogen fixation

One of the main factors restricting vegetation restoration is soil degeneration. For instance, the content of organic matter in the hill-slope soil of Heshan is only 0.6–1.6% before restoration (Liao *et al.* 1984). Improving soil fertility and physical chemical property are fundamental steps for restoration (Ding & Yi 1989). A distinguished characteristic of *A. auriculiformis* is the strong nitrogen-fixing ability of its root nodules. According to the observation at Xiaoliang station, most nodules, 5–10 cm from the surface grow on fibrous roots. Only a few are on axial root. The nodules, which were oblong and red formed in April and flourished in July. When matured they turned into rhabditiform or furcation measuring over 1 cm in length. In November the nodules became bistre and runt, indicating their senility. The determination at Xiaoliang station showed that the nitrogen-fixing activity of four-year-old forests in April was 0.08 μmol (C_2H_4) g^{-1}(fresh nodule) h^{-1} and reached 5.84 μmol(C_2H_4) g^{-1}(fresh nodule) h^{-1} in July, but in November the activity gradually declined because of senility, which represented an evident seasonal variation (Liao *et al.* 1984). At the Heshan station, the nodules biomass of seven-year-old forests was 3.22×10^{-3} kg m^{-2}, while the nitrogen-fixing activity from May till August was 3.5–4.6 μmol (C_2H_4) g^{-1}(fresh nodule) h^{-1} and 2.0–3.1 μmol (C_2H_4) g^{-1}(fresh nodule) h^{-1} from November till April next year. The total nitrogen fixation of this community was 8.7×10^{-4} kg m^{-2} a^{-1}, which indicated the potential to improve soil fertility.

Litter dynamics

The litter quantity of five- and six-year-old forest at Heshan station was 3461 kg m^{-2} and 0.6542 kg m^{-2} respectively (Li *et al.* 1990). This corresponded to the values of many natural forests (Edwards 1977, 1982, Proctor 1983). The values showed that litter quantity increased rapidly with forest age. It took about two years for complete decomposition of this litter through termite action and micro-organism activity. Therefore, many nutritional elements can be released into soil and reused by plants within a short period, which has a very important significance on ecosystem recovery.

Soil animals

In the barren land of Xiaoliang station, the total biomass of soil animals was only 0.33 g m^{-2} (Liao 1990), while in the seven- and nine-year-old man-made forests many soil animal populations appeared such as Nematoda, Gastropoda, Homoptera, Lepidoptera, Coleoptera and Hymenoptera, and the total biomass was 18.0 g m^{-2}. The development trend of soil animal communities can be displayed by the density-group index. The possible trend was classified as three intervals (Figure 9). The first interval, from plantation time to the 11th year, was a significant growth period, in which the animal species and quantity increased rapidly, especially the insect species. The second, from the 12th to 20th year, was a transition period, in which the density-group index fell gradually. The third one, over 20 years, was a stable period in which the community structure was maintained for a long time.

Simulation of growing dynamics

Successful recovery depends on construction and maintenance of effective nutrient cycling as well as reduction of loss of nutrient in forest ecosystems. From 1978, Xiaoliang station, in co-operation with Kassel University in Germany, carried out systemic studies and computer simulation on man-made forest dynamics in erosional areas of south China. An ideograph of carbon and nitrogen storage and

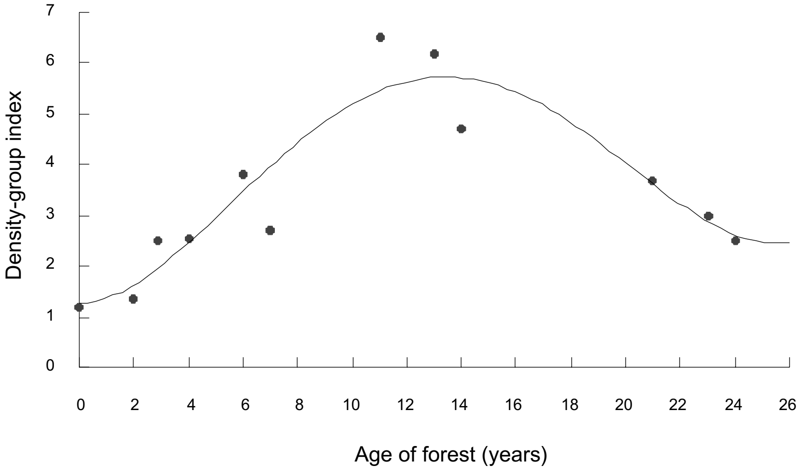

Figure 9 Density-group index of soil animal community in artificial mixed forest, Xiaoliang

flow in the 10-year-old forest was established (Figure 10). Meanwhile, the dynamics of 10-year-old forest were simulated with the DYSAY program, later ascertaining the sensitive parameters through measuring a large quantity of physiological indices and environmental factors. It was classified into two simulation situations, one with abundant nitrogen resources and the other with nitrogen limitation.

The net increment of timber biomass of *A. auriculiformis* forest without nitrogen limitation was simulated (Figure 11). The productivity of the forest was high in the early years and timber production reached peak value in the ninth year. After that, the net increment declined visibly. The timber biomass of 10- and 20-year-old forests were 57 and 85% of the final biomass production respectively.

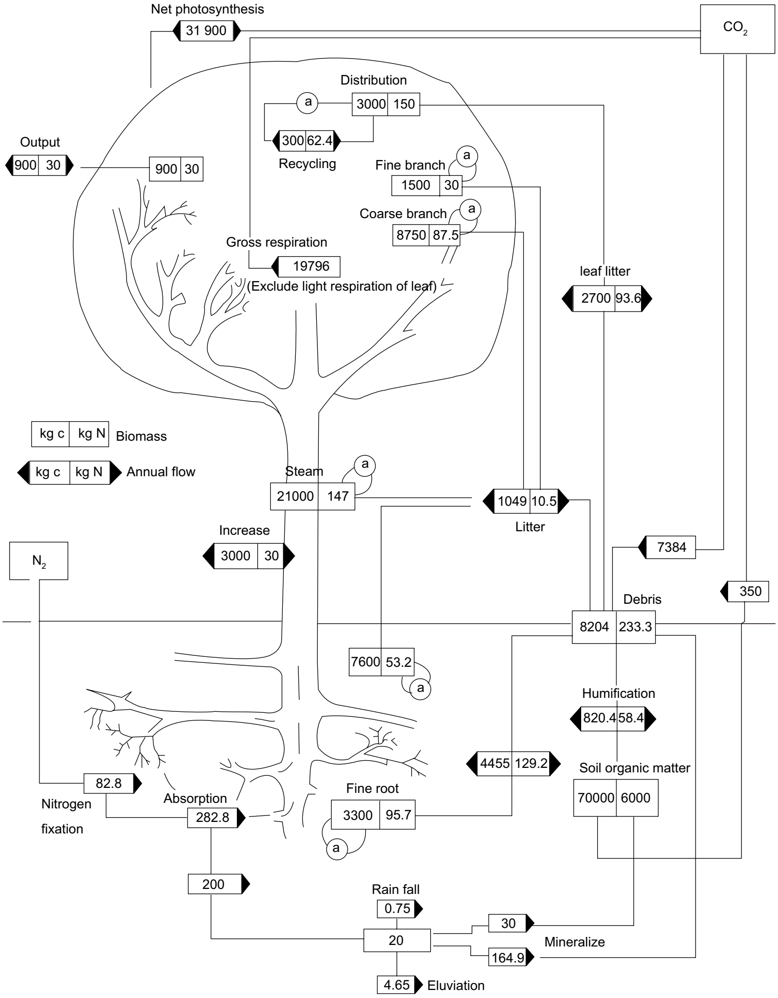

Figure 10 Ideograph of carbon and nitrogen storage and flow in the 10-year-old *Acacia auriculiformis* forest (Unit area is one hectare. Bossel 1986)

The amount of assimilation was reduced due to nitrogen limitation (Figure 12). Under such circumstances, the net increment rate of photosynthetic production maximized in the 12th year, which was lower than that of forest without nitrogen limitation. On the other hand, the timber increment was higher and the decline trend lower after the 13th year. The timber biomass of 10- and 20-year-old forests were 36 and 77% of the final biomass production respectively. After the 25th year, the forest with nitrogen limitation had higher timber production because the quantity of fruits was low, which resulted in a reduction in nitrogen output. In short, the simulation results indicated that the maximum net increment of timber biomass of *A. auriculiformis* forests lasted from the ninth to 12th year and then declined gradually.

Eco-security and function assessment

Species introduction is becoming the main source of exotic tree invasion. However, no reports showed that *A. auriculiformis* species has strong ability of invasion and devastation in lower subtropics of China. The vegetation restoration practice in south China had also demonstrated that *A. auriculiformis* had no negative

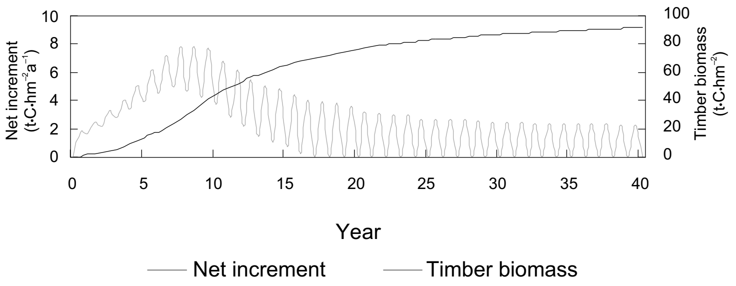

Figure 11 Simulation result of growth and net increment of timber biomass of *Acacia auriculiformis* forest without nitrogen limitation

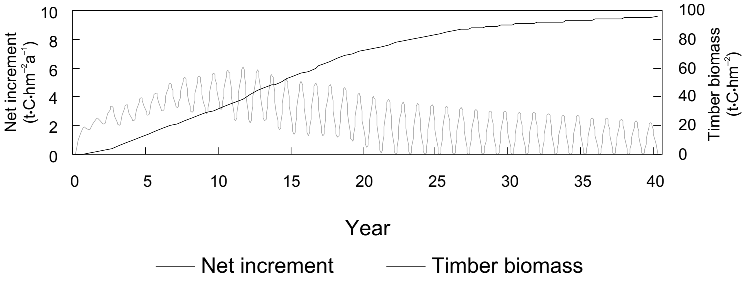

Figure 12 Simulation result of growth and net increment of timber biomass of *Acacia auriculiformis* forest with the maximum nitrogen fixation rate of 50 kg ha^{-1} a^{-1}

impact on the local ecosystem. On the contrary, they formed pioneer forests, improving habitat condition and biodiversity. The growth potential of plants is great if heat and rainfall are sufficient. The major ecological factor affecting growth of forest trees in degraded hills is the poor quality of soil (Peng *et al.* 1992). *Acacia auriculiformis* grew fast to form good forest overlay in degraded weedy slopes and wastelands so that the conditions of temperature, humidity and soil fertility in the forest are improved. It could provide a good environment for shrubberies and other species, especially some of the native species with better adaptability to immigrate and settle down. From the point of succession, the structure and environment of artificial *A. auriculiformis* forest are relatively close to zonal landscape, such as retrogression of xerophytic grass, invasion of some climax species, increasing biodiversity and the tendency of community succession to zonal evergreen monsoon broad-leaved forest of the southern subtropics. Therefore, *A. auriculiformis* must be considered an ecologically safe tree species.

The growth rate of *A. auriculiformis* trees was rather rapid during the early years after planting, but this tendency began to decline from the fifth year. The systemic simulation result, showing the net increment of timber biomass declining rapidly after 10 years, coincided with the field observation. In addition, its resistance to wind is poor because its root system, with lots of thin roots is shallow in the soil. Meanwhile, the reason why it cannot form a natural renewal layer at Heshan station may be that the latitude is higher than that of its provenance, which causes the accumulated temperature cannot reach the desired level (Ren *et al.* 2000). Due to these factors, *A. auriculiformis* can only act as a good pioneer instead of a dominant tree species of stable community. Some adequate and conscious measurements, including improvement cutting and introducing native species should be taken to reconstruct the forest in appropriate time so as to accelerate the process of ecological restoration.

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