STATUS AND PERSPECTIVES ON SECONDARY FORESTS IN TROPICAL CHINA

Z. Zaizhi

Research Institute of Tropical Forestry (RITF), Chinese Academy of Forestry, Guangzhou 510520, P. R. of China

ZAIZHI, Z. 2001. Status and perspectives on secondary forests in tropical China. Tropical China has relatively low forest cover and faces high pressures for its depleting forests. Following intensive exploitation of its forest resources over several decades, large areas of post-extraction secondary forests exist. These remaining natural forests play very important roles in water resources retention, and the supply of small-diameter timber, fuelwood, poles, and non-timber forest products for sustaining the livelihoods of mountain communities. However, the extent of these resources is fast diminishing and most of it is highly degraded.The paper illustrates that the transfer of forest-use rights to local communities can in fact lead to increased forest degradation when implemented in the context of a long history of changing policies on forest-use rights. The paper also suggests that a shortage of financial support, incentive mechanisms, management knowledge and techniques, the over-taxation of wood, and poverty are affecting the management and use of secondary forests. Policy requirements and management options need to be explored for overcoming the constraints to the ecologically and economically viable use of secondary forests, and the integrated development of the communities that depend on this resource.

Key words: Tropical China - secondary forests - mountains - degraded land - local communities - policy change

ZAIZHI, Z. 2001. Status dan perspektif terhadap hutan sekunder di tropika China. Secara relatif tropika China mempunyai litupan hutan yang rendah dan tekanan yang tinggi secara relatif. Ekoran eksploitasi secara intensif terhadap sumber hutan sejak beberapa dekad, wujud kawasan hutan sekunder selepas pengekstrakan yang luas. Hutan semula jadi yang masih tinggal memainkan peranan yang sangat penting sebagai penahan sumber air, dan pembekal balak bergaris pusat kecil, kayu api, kayu jaras serta keluaran hutan bukan-kayu untuk mengekalkan mata pencarian penduduk di kawasan pergunungan. Bagaimanapun, sumber-sumber ini berkurangan dengan cepat dan kebanyakannya rosak dengan teruknya. Artikel ini menerangkan bahawa pengalihan hak penggunaan hutan kepada penduduk tempatan menyebabkan pendegradan hutan meningkat apabila dilaksanakan dalam konteks sejarah pertukaran polisi tentang hak penggunaan hutan. Artikel ini juga mencadangkan bahawa kekurangan sokongan kewangan, mekanisme pemberian insentif, pengetahuan dan teknik pengurusan, di samping cukai yang tinggi ke atas kayu serta kemiskinan memberi kesan kepada pengurusan dan penggunaan hutan sekunder. Keperluan polisi dan pilihan pengurusan perlu diteliti untuk mengurangkan tekanan kepada penggunaan hutan sekunder yang berdaya maju dari segi ekologi dan ekonomi, dan pembangunan bersepadu penduduk yang bergantung kepada sumber-sumber ini.

Introduction

The tropical zone of China includes Hainan Island, Taiwan Island, and the southern part of the Yunnan, Guangdong and Guangxi provinces (Figure 1). It covers an area of 2.65 million ha on the mainland, approximately 2.8% of China's total land area. The forest land covers an area of 1.41 million ha, consisting of 0.52 million ha of natural forests (not including swidden fallows), 0.34 million ha of plantation areas, and 0.55 million ha of degraded lands (Chinese State Forestry Administration 1994).

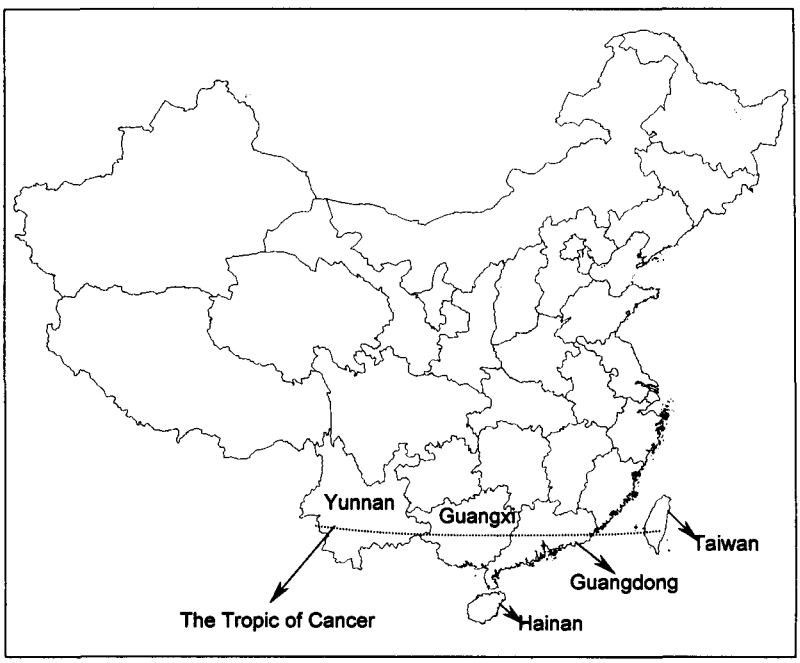

Figure 1 Tropical zone of the People's Republic of China

The highlands and mountain areas comprise 80% of the total area of tropical China. Tropical evergreen broad-leaved forests, tropical monsoon forests (from 100 to 600 m asl) and rain forests (from 600 to 1100 m asl) are the typical forest vegetation types. Rapid population growth and an increasing demand for timber and non-timber forest products (NTFPs) in recent decades have resulted in the widespread transformation of primary forests to secondary forests. Secondary forests are defined here as 'forests regenerating largely through natural processes after significant human disturbance of the original forest vegetation at a single point in time or over an extended period, and displaying a major difference in forest structure and/or canopy species composition with respect to nearby primary forests on similar sites' (Chokkalingam *et al.* 2000).

Tropical China currently has relatively low forest cover and faces high pressures for its depleting forest. Only 72 200 ha of tropical primary forests remain (Xue & Jiang 1986, Zeng *et al.* 1997); secondary forests occupy 446 230 ha or 86.1% of natural forests and 31.5% of the forestland in tropical China. Given the progressively increasing importance of secondary forests, it is imperative that these be managed and used sustainably.

Role and importance of secondary forests

Secondary forests provide a rich natural resource base and habitat for wildlife. They also provide timber, small-diameter wood, fuelwood and poles of importance to the wood and charcoal industry and to the livelihood of the mountain communities. In addition, these forests also play an important role in watershed and soil protection.

Small-diameter wood

Secondary forests are a growing source of small-diameter wood for industrial use as illustrated by the case of Cangwu County in southern Guangxi Province. Cangwu County has approximately 67 600 ha of logged-over secondary forests, making up 26% of the total forest area. After repeated logging practised by several generations, these forests now yield only small-diameter wood. In the past, over 80% of the wood production was used as fuelwood and charcoal, and the remaining 20% for producing farming tools.

However, in the 1990s, the situation changed. With the development and establishment of large-scale wood processing factories and private, small wood-processing mills, the demand for small-diameter wood increased. The annual demand for small-diameter wood grew to 1 800 000 tons, 88.6% consumed by the wood industry and 11.4% used for producing farming tools and as fuelwood. The present capacity for supplying small-diameter wood in the county is around 900 000 tons, just half of the demand. In 1996, in the village of Shanxin in Cangwu County, which has relatively high forest land (0.95 ha) per capita (Guangxi Forestry Academy for Planning and Design 1986), almost all of the farmers' cash income came from selling small-diameter wood and fuelwood (Zheng *et al.* 1996).

Fuelwood

In mountainous and rural areas of tropical China, fuelwood is the primary source of energy for domestic use, agriculture and other production, such as roasting tobacco and baking bricks. Local people largely depend on fuelwood as the source of bio-energy. In Hainan Island, the consumption of fuelwood accounts for half of the total wood consumption (Jiang & Lu 1991). In Xishuangbannan, Yunnan Province, the proportion is over 66% (Zhu 1995).

Plant resources of economic value

Although secondary forests are being continuously degraded, they still contain a wealth of plant species of economic value. In the secondary forests of the village of Shanxin, there are approximately 280 species of medicinal plants, 80 species of oil plants and 20 species of fibre plants, as well as some valuable timber species, such as *Castanopsis hystrix* and *Erythrophloeum* sp. (Zeng *et al.* 1998). This richness of plant resources represents an economic potential for utilisation in the near future.

Watershed and soil protection

Zhou *et al.* (1995) carried out a research on the streamflow of secondary forests in Jianfengling, Hainan Island. An experiment watershed of 3.1 ha, covered by naturally regenerating tropical mountain rain forest (clearcut in 1965), was established in 1989. The results indicated that secondary forests in good condition had more positive hydrological effects compared to Chinese fir and *Eucalyptus* plantations, in terms of reducing peak flood discharge, delaying flooding and increasing runoff in the dry season.

Formation and transformation of secondary forests

Before the establishment of the People's Republic of China in 1949, natural forests in tropical areas had been affected by war, overlogging and forest fires (Wu *et al.* 1997). After 1949, deforestation and degradation accelerated. Currently, most remaining natural forest areas are secondary and are subject to high degradation pressures. The leading factors or forces that have led to the formation and transformation of secondary forests are discussed below.

Overlogging and illegal logging

Intensive logging from the 1950s to 1980s was responsible for most primary forest degradation to post-extraction secondary forests in China (Figure 2). Post-extraction secondary forests are defined here as 'forests regenerating largely through natural processes after significant reduction in the original forest vegetation through tree extraction at a single point in time or over an extended period, and displaying a major difference in forest structure and/or canopy species composition with respect to nearby primary forests on similar sites' (Chokkalingam *et al.* 2000). There were three major logging episodes in the last 50 years. During the 'Great Leap Forward' and 'Iron-and-Steel Making' Campaigns in 1959, people were mobilised to cut trees randomly for the iron and steel industries. During the 'Great Cultural Revolution' (1966–1976) management systems were not operative and tropical forests were overlogged for timber and charcoal production.

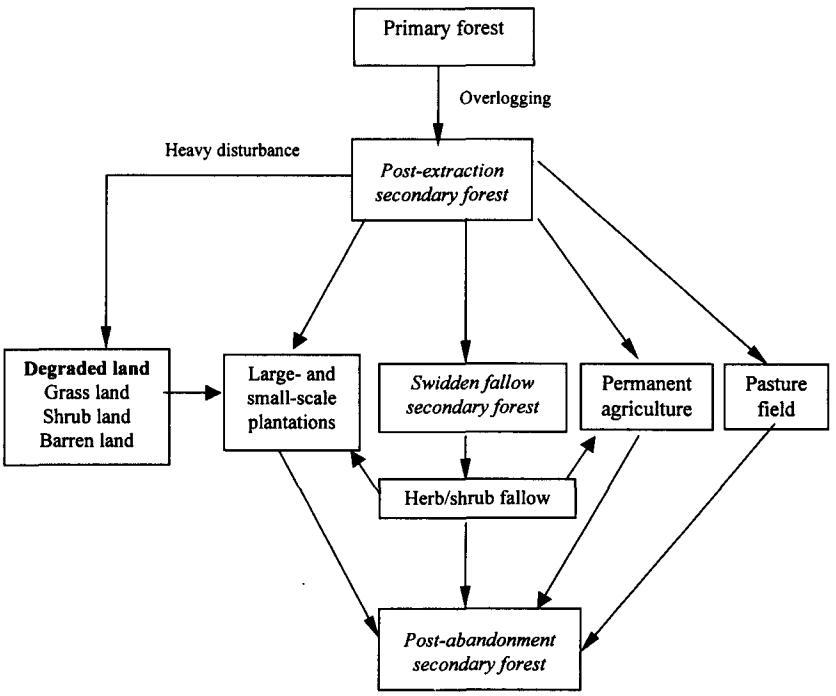

Figure 2 Conceptual dynamic model of the formation and transformation of secondary forests in tropical China

In order to protect and better manage forests for various products, tenure rights were granted to households in 1981 to 1983 by distributing family plots and delegating forestry production responsibility (Dachang 2001). When the decision was implemented, the third serious deforestation event occurred. Frequent changes in land tenure—from individual ownership, to collective ownership after 1949, to household ownership again in 1981—led to a lack of farmers' confidence in tenure security. This resulted in farmers instantaneously felling all the big and valuable trees when the forests were contracted to them in 1981.

Post-extraction secondary forests comprise over 80% of the total area of secondary forest. A nationwide inventory reveals that 58.7% of this type of secondary forest in tropical China is non-State forest (Chinese State Forestry Administration 1994). Logging in the forest is banned in Hainan, and prior permission is needed for logging in the other provinces. However, illegal logging for timber and fuelwood is common and especially severe in some poor areas. The forests managed by collectives and farmers face further degradation, particularly in some areas of Guangxi, with clearcutting at 5- to 6-years intervals. In Guangdong, Hainan and Yunnan, the collectives own 90% of the secondary forests and illegal cutting is not as severe as in Guangxi. Despite their degraded condition, post-extraction secondary forests are still important to the local people's livelihoods, and play a vital role in watershed protection.

Swidden agriculture

Swidden agriculture has been practised for a long time in tropical China, particularly in the minority nationality area of Hainan Province and Yunnan Province, and is estimated to cover an area of over 400 000 ha. Approximately 20% of the natural forests in tropical China have been transformed by swidden agriculture (Wu & Zhou 1996). In Hainan alone, there are over 40 000 farmers practising swidden agriculture. In remote areas where populations are sparse, swidden agriculture has long fallow periods and leads to the formation of swidden fallow secondary forests (Figure 2). Swidden fallow secondary forests are defined here as 'forests regenerating largely through natural processes in woody fallows of swidden agriculture for the purposes of restoring the land for cultivation again' (Chokkalingam *et al.* 2000). In other areas, fallows are shorter. Overall, with rising population pressures and the scarcity of agricultural land, the fallow periods were reduced from 7–8 years in the 1970s and 1980s to 4–6 years in the 1990s, reducing the potential for swidden fallow secondary forest formation.

Since 1982, the governments of Yunnan and Hainan have formulated a series of special policies and measures to halt the practice of swidden agriculture (Zhu 1995). These include exemption from agricultural tax, the establishment of new residential zones and stable arable land for permanent cropping, and the allocation of small areas of forestland to farmers as family plots for developing economic plantations and agroforests (Chen 1982, Wang 1983, Yu 1984, Zeng *et al.* 1997).

Forest fire

Natural fires are not common in southern China because of the humid climate; and most forest fires are induced by human activities. In recent years, almost no fires have occurred in primary forests since they were protected. The situation is different in secondary forests, where human-induced fires are common. According to the Chinese State Forestry Administration (1994), there were 276 000 ha of burnt land in tropical China. The restoration of these lands largely depends on natural regeneration, but there are no precise statistical data on the area of post-fire secondary forest in tropical China. Post-fire secondary forests can be defined here as 'forests regenerating largely through natural processes after significant reduction in the original forest vegetation due to a catastrophic human-induced fire or succession of fires, and displaying a major difference in forest structure and/or canopy species composition with respect to nearby primary forests on similar sites' (Chokkalingam *et al.* 2000).

Conversion to plantations and agriculture

In the 1960s, large tracts of secondary forests were clearfelled and replaced with pine, Chinese fir and rubber trees by the State forest farms of Guangdong, Guangxi, Yunnan and Hainan (Figure 2). Similar pressures led to the conversion of secondary

forests to permanent agriculture. Low market prices and high taxes for timber led to the conversion of some secondary forests owned by farmers to small-scale economic plantations.

Abandonment of alternative land use

Some plantation forests, particularly pine plantations, failed due to poor site matching, repeated logging, and poor management, and were abandoned, leading to the formation of post-abandonment secondary forests (Figure 2). Post-abandonment secondary forests are defined here as 'forests regenerating largely through natural processes after total abandonment of alternative land use (plantations, agriculture, pasture, etc.) on formerly forested lands' (Chokkalingam *et al.* 2000). Also, overlogging in mature pine and Chinese fir plantations, as well as a lack of tending and enrichment planting after harvest, caused severe degradation. These plantations were subsequently abandoned, leading to the formation of post-abandonment secondary forests with natural regeneration.

With the opening up of the Chinese economy to the outside world in 1978, poor farmers living in remote mountainous areas began to abandon dryland agriculture and move to cities and wealthier provinces seeking non-farm work. This phenomenon is common in Guangxi Province. With the development of the market-oriented economy in the 1990s, some State-owned or collective-owned pasture farms for raising cattle and sheep were closed down because of poor profits in provinces across tropical China. Natural regeneration appeared on the abandoned pastures and gradually developed into post-abandonment secondary forests (Figure 2). The estimated proportion of post-abandonment secondary forest is 10 to 15% of the total area of secondary forests in tropical China, and primarily consists of regeneration with the abandonment of plantations.

Rehabilitation of degraded lands

Secondary forests subject to heavy logging, repeated fires and poor management became degraded lands (Figure 2). Degraded lands are defined as 'formerly forested lands severely impacted by intensive and/or repeated disturbance (such as mining, repeated fires, or overgrazing) with consequently inhibited or delayed forest re-growth. These include barren areas, *Imperata* grasslands, brushlands, and scrublands' (Chokkalingam *et al.* 2000). There are large areas of degraded land in tropical China, mostly belonging to the collectives and constituting 39% of the total area of forestland. However, there is very limited area in rehabilitated secondary forest derived from natural regeneration of degraded lands. Rehabilitated secondary forests are defined here as 'forests regenerating largely through natural processes on degraded lands, often aided by rehabilitation efforts, or the facilitation of natural regeneration through measures such as protection from chronic disturbance, site stabilisation, water management, and planting' (Chokkalingam *et al.* 2000). From 1985 onwards, the governments of Guangdong, Guangxi, Yunnan and

Hainan initiated major tree planting projects to recover their degraded lands within 5 to 10 years for environmental purposes.

Status and management of secondary forests

Current status

In tropical China, more than 80% of the secondary forests are in poor condition, with low stocking and less valuable species. The average stocking volume of tropical secondary forests is approximately 94.7 m^3 ha^{-1} in Yunnan, 54.7 m^3 ha^{-1} in Guangdong and 22.2 m^3 ha^{-1} in Guangxi (Guangxi Forestry Academy for Planning and Design 1986, Xue & Jiang 1986, Liu *et al.* 1991).

Different forest land tenure and distances to residential areas may lead to different forest conditions. Table 1 illustrates the point in terms of biomass. Post-extraction secondary forests near residential areas were mostly distributed to farm households in the 1980s. These forests became sharply degraded under farmer management. Forest biomass declined from 36.22 t ha^{-1} after the first harvest to 21.07 t ha^{-1} after the second harvest. If the forests are harvested continuously they will gradually degrade into barren land. Fuelwood shortage may become serious in the near future. On the other hand, secondary forests far from residential areas or under the control of State forest farms seem to have relatively high biomass.

Table 1 Distribution of aboveground biomass in tropical secondary forests in China

Province	Secondary forest type	Ownership	Aboveground biomass (t ha^{-1})				
			Age (years)	Trees	Shrubs	Grasses	Total
Hainan Island[a]	Post-extraction secondary forest (permanent plot in Jianfengling Forest Reserve)	State	26	167.97	1.92	8.278	272.91
Yunnan[b]	Post-extraction secondary forest	State	42	158.95	2.37	0.89	162.56
Guangdong[b]	1. Protected forest in Dinghushan Forest Reserve	State	100	353.52	3.81	0.64	357.98
	2. Post-extraction secondary forest	Community	29	192.8	6.2	-	199.0
Guangxi[c]	1. Post-abandonment secondary forest	Household	35	79.81	0.97	1.28	80.06
	2. Post-extraction secondary forest	Household	8(1)	33.59	2.18	0.45	36.22
	3. Post-extraction secondary forest	Household	8(2)	18.06	1.6	1.41	21.07

Values in brackets represent frequency of felling after forests were distributed to households in the 1980s.
Sources: a: Zeng *et al.* 1997
b: Chen *et al.* 1996
c: Zeng *et al.* 1998

Protection in tropical forest reserves leads to the development of better-quality secondary forests. Numerous tropical forest reserves were set up by the Chinese government since the late 1950s in both tropical primary forests and some post-extraction secondary forests with protection value. In Hainan Island, the total area of protected tropical forests reached 768 km^2 in 1990, making up 21% of the total area of tropical natural forests (Zhu 1995). Yunnan Province has the highest proportion, 21.6% (Zhang & Li 1997). Most secondary forests situated outside the reserves are in poor condition.

Administration and management practices

In the early 1950s, the rehabilitation of secondary forests depended largely on natural regeneration although the State advocated protecting forests, reforestation and 'closing mountains'[1] for natural regeneration. In the 1960s the strategy for forest management shifted from timber cutting to reforestation (Liu *et al.* 1991). During this period, the replanting of severely degraded post-extraction secondary forests in remote mountain areas relied on sowing by plane, mainly with pine species. In more accessible areas, however, these forests were clearcut and replaced manually with timber plantations. Since 1978 the central government has formulated a number of policies for forest protection and reforestation. Based on these policies, some provinces in tropical China have formulated corresponding conservation measures for tropical forests such as 'closing mountains', a ban on the logging of natural forests, and the establishment of protected areas of primary and secondary forests.

After the devastating floods of 1998, the Chinese government initiated a program of natural forest protection for warding off environmental deterioration, protecting biodiversity and facilitating sustainable development of the society and the economy. The program covers 18 provinces, including Yunnan and Hainan. According to this program, logging in natural forests is prohibited. It is believed that the program will greatly contribute to the protection of tropical forests and the rehabilitation of secondary forests (Zhang *et al.* 1999).

Presently, the management of secondary forests in less accessible areas primarily depends on the 'closing mountains' measure to accelerate forest rehabilitation. In accessible areas, enrichment planting of secondary forests with native species is being practised in some rich State forest farms and communities. For the management of severely degraded secondary forests, the common practice is to establish plantations after clearcutting.

[1] 'Closing mountains' means totally prohibiting access to the mountain areas.

Technical and socio-economic constraints to secondary forest rehabilitation and management

Poverty

Poverty is an underlying cause of deforestation and the conversion of primary forest to secondary forests and degraded lands in tropical China. Farmers in most mountain regions have limited cultivation land with low crop yield, and fell trees to earn cash for meeting their basic needs. However, farmers are unable to invest in enrichment planting and the tending of forests. Consequently, the forests become further degraded. In some counties of Guangxi province, post-extraction secondary forests are regarded or managed as fuelwood forests now.

Lack of incentive measures and over-taxation of wood

Reforestation is an official government policy. In some places, workers and farmers in the forest farms or in the communities are mobilised and asked to plant trees in post-extraction secondary forests and degraded lands owned by the collectives. This is regarded as their duty, and no wage is paid for labour, or it is inadequate and delayed. A lack of incentives has led to low enthusiasm in tree planting and tending efforts, and low survival rates for seedlings.

Taxation is a means to distribute benefits and, to some extent, a mechanism to regulate economic behaviour. A rational tax policy encourages investment. By contrast, the overcharging of taxes and fees affects incentives for investments (Wu 1993). Local governments and forest agencies collect and charge 14 different kinds of taxes and fees on timber in Cangwu County, Guangxi Province. Consequently, farmers have to pay nearly half of the sale price of timber/wood as taxes. Taking into account the costs of logging and timber transportation, generally agreed to be between 30 and 40% of the market price for wood or timber, farmers earn an income of 10 to 23% of the sale price. On average, it was estimated that farmers can get an income of 15% of the sale price. When the costs of tree planting and tending are taken into account, the net income of farmers from timber production is nearly zero (Zheng *et al.* 1998). Therefore, farmers have no incentive to maintain their secondary forests or grow timber trees. They sell their wood as fuelwood even though prices for fuelwood are much lower than those for timber, since fuelwood sale is not subject to high taxation. Most farmers would rather convert the forests to agriculture or economic plantations.

Lack of silvicultural knowledge and techniques

In tropical China, more attention has been paid to research on the ecology of secondary forests dealing with, among others, biomass and productivity, structure, function and successional development in protected areas (forest reserves). Research efforts on silviculture, particularly with regard to the selection and cultivation of

valuable native tree species, site matching, planting options and accelerating natural regeneration by artificial means are lacking. These gaps in silvicultural knowledge and techniques for rehabilitating natural secondary forests have indirectly favoured the wide employment of plantations using single tree species, such as pines, Chinese fir, *Eucalyptus* and *Acacia* in southern China.

Lack of effective management and supervision

Since the founding of the People's Republic of China, the forestry industry has primarily depended on timber supplied by State forest enterprises and collective forest farms, whose essential role in the long term was to cut trees for industrial timber production. There was no concern for forest regeneration and management on a sustainable basis (Xue & Jiang 1986, Liu *et al.* 1991). Both clearcutting and selective logging were commonly and frequently used, resulting in large areas of low-yield secondary forests and degraded land. The lack of sound logging techniques, effective silvicultural measures combining thinning, regeneration and tending, as well as good supervision, caused a decline in forest quantity and quality. To date, there is no sound and effective regulation for managing and utilising natural forests on a sustainable basis (Li 1997).

Lack of better alternatives and sound mechanisms for 'closing mountains' at the community level

In order to protect natural forest resources, a total ban on logging in natural forests was formulated as a national policy in 1998. In addition to this, some provinces formulated and implemented a plan of 'closing mountains' to prohibit access to mountain areas and to help poorly stocked natural secondary forests recover. These measures were easy to implement at the forest farm level through production and management responsibility systems. However, at the community level, it was unclear as to how to organise and encourage local farmers to pool their forestland and to participate in the plan. In some closed mountains, illegal logging is quite heavy. The direct and effective participation of communities, with clear identification of the 'responsibilities', 'rights' and 'benefits', is required for the success of the 'closing mountains' programme.

Lack of funding

Little funding and investment has been allocated for the sustainable management and monitoring of both protected and non-protected secondary forest areas for timber and non-timber forest products, biodiversity and environmental values. Secondary forests overall receive less research priority and attention than do plantations or primary forests.

Conclusion

In mainland tropical China, natural forest cover is limited to 20% of the land area and 86% of that is secondary, arising largely from numerous episodes of intensive logging since the 1950s. These remaining secondary forests are important for protecting the environment and improving people's livelihoods. They serve as sources of small-diameter wood, fuelwood, poles and NTFPs of importance to industry and the mountain communities. However, most secondary forests face serious threats of degradation. It is important to determine the current state and degree of degradation of the different secondary forest types and explore alternative rehabilitation and management options for ensuring ecologically and economically viable use, and the integrated development of the communities that depend on this resource.

To manage secondary forests on a sustainable basis, it needs to be recognised that these forests are the result of a complex mix of technical, socio-economic, policy and institutional factors. A sound management model for secondary forests should be based on the willingness for mutual collaboration between the government and the people living on the fringes of secondary forest areas. Strategies are required to allow the establishment of management guidelines in co-operation with communities, with visible benefits accruing to the latter as well.

Other constraints to the rehabilitation and management of secondary forests include limited silvicultural knowledge with regard to native species and disincentives such as the over-taxation of wood. There is a need to improve our knowledge of secondary forests and how to manage them. For instance, we need to gain information on the dynamics of the successional development of different types of secondary forests; enrichment planting techniques with valuable native tree species in post-extraction secondary forests; the artificial replanting and regeneration of forest gaps; patterns of regeneration of native tree species; and the establishment of mixed forests. Incentive measures conducive to community and private enterprise and investment in sustainable secondary forest management need to be identified and promoted.

Acknowledgements

Thanks to G. A. D. Perera, R. Effendi and L. Dachang for providing useful comments on this manuscript.

References

CHEN, C. 1982. About the development, construction and natural conservation of Xishuangbanna. *Natural Resources* 2: 90–96.

CHEN, Z., WANG, B. & ZHANG, H. 1996. Pp. 69–70 in *Productivity of the Lower Subtropical Evergreen Broad-Leaved Forest in China.* High Education Press of Guangdong Province.

CHINESE STATE FORESTRY ADMINISTRATION. 1994. *The Statistics of State Forest Resources (1989–1993).*

CHOKKALINGAM, U., DE JONG, W., SMITH, J. & SABOGAL, C. 2000. Introduction. Paper prepared for the "Tropical secondary forests in Asia: Reality and perspectives' workshop". 10–14 April 2000. Samarinda, Indonesia. Center for International Forestry Research, Bogor, Indonesia.

DACHANG, L. 2001. Tenure and management of non-state forests in China since 1950: a historical review. *Environmental History* 6(2): 239–263.

GUANGXI FORESTRY ACADEMY FOR PLANNING AND DESIGN. 1986. *Report of Forest Division of Guangxi.*

JIANG, Y. & LU, Z. 1991. Pp. 284–289 in *Tropical Forest Ecosystem in Jianfengling, Hainan Island.* Science and Technique Publishing House, Beijing.

LI, G. 1997. A view of the sustainable management of the tropical natural forest of Hainan. Pp. 167–171 in *Proceedings of the International Symposium on the Sustainable Management of Tropical Forests.* 9–13 December 1997. Haikou, Hainan.

LIU, J., QIU, G. & CHEN, Z. 1991. *Guangdong Forestry in the Mountain Region.* Guangdong Science and Technique Publishing House, Guangzhou.

WANG, H. 1983. The main characteristics and rational utilisation of land resources in Xishuangbanna. *Natural Resources* 2: 26–32.

WU, Y. 1993. Reducing burden on farmers and promoting forest development. *Forest Economy* 1: 48–50.

WU, Z., WANG, Z. & LINYING (Eds.). 1997. Pp. 176–179 in *China's Forests.* China Forestry Publishing House, Beijing.

WU, Z. & ZHOU, G. 1996. Ecological consequences of slash-and-burn agriculture in the tropical areas of China. *Journal of the Human Environment* 25(3): 210–211.

XUE, J. & JIANG, H. (Eds). 1986. *Yunnan's Forest.* Yunnan Science and Technique Publishing House, Kunming.

YU, X. 1984. The ecological environment of the mountainous areas and establishing agricultural systems in the mountain range of Hainan Island. *Tropical Geography* 4(1): 1–8.

ZENG, Q., LI, Y. & CHEN, B. 1997. *Research and Management of Tropical Forest Ecosystems.* China Forestry Publishing House, Beijing.

ZENG, J., WENG, Q., ZHENG, H. & ZHOU, Z. 1998. Study on degradation status and development potential of secondary forest of the village of Shanxin in Cangwu county. *Guangxi Forestry Science* 27(4): 174–180.

ZHANG, P., ZHOU, X. & WANG, F. 1999. Pp. 23–24 in *Introduction to the Natural Forest Protection Program.* China Forestry Publishing House, Beijing.

ZHANG, Y. & LI, Y. 1997. The status and sustainable management of tropical forest in Yunnan. Pp. 196–202 in *Proceedings of the International Symposium on the Sustainable Management of Tropical Forests.* 9–13 December 1997. Haikou, Hainan.

ZHENG, H., ZHOU, Z., ZENG, J. & WENG, Q. 1996. Diagnosis report of the project Alternative Socio-Economic Approaches to Reclaiming Degraded Lands in Tropical China. Research Institute of Tropical Forestry, China.

ZHENG HAISHUI, ZHOU ZAIZHI, ZENG JIE & WENG QIJIE. 1998. Final report of the Project Alternative Socio-economic approaches to reclaiming degraded lands in tropical China. Research Institute of Tropical Forestry, China.

ZHOU, G., ZENG, Q. & HUANGQUAN. 1995. Stream flow of a tropical mountain forest watershed in Jianfengling, Hainan Island. Pp. 111–119 in Zeng, Q., Zhou, G. & Li, Y. (Eds.) *Research on Tropical Forest Ecosystems in Jianfengling of China.* China Forestry Publishing House, Beijing.

ZHU, H. 1995. The current status and utilisation of tropical forest resources and the perspective of their development in 2000. *World Forest Research* 8(5): 52–57.