FOREST TRANSITION

Deforestation and Forest Transition: Theory and Evidence in China

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Abstract: A general theoretical framework on deforestation and forest transition is presented followed by empirical evidence from China. Relative scarcities of food, timber and environmental goods resulting from both population and economic growth are believed to be the most fundamental causes of forest change. A relative scarcity of population – a factor of production as well – is considered to drive population change and re-allocation. The time required from deforestation to forest transition may be prolonged by the time lag in forest regeneration, and by the transaction costs, i.e. the costs in transferring, defining and protecting property rights of land and forests. The institutional issue is specially addressed throughout this article because the "exclusion cost", i.e. the *ex post* cost of transaction in property rights of land and forests, is relatively large compared with other aspects of property protection. Consequently, active forest management is not economically justified on a large part of land which otherwise should be under active management. This article concludes with a preliminary forecast of the future trend in China's forests and policy implications on future forest development.

Keywords: Deforestation; forest transition; reforestation; transaction costs; economic reform; land use; population; China.

1 Introduction

While the forests in the developed countries have ceased to shrink in area and have even begun to expand – a reversal which in this article is called forest transition – the developing countries are still in the deforestation stage. The growing demands of an increasing population for agricultural land and for timber are widely recognized as the most important causes of deforestation. However, the scarcity of timber, and industrialization are generally viewed as accounting for forest transition (Rudel 1998). Both conclusions seem to conflict each other but are likely to be correct. The

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problem is that we do not identify the origins of forests and analyze them separately based on the origins. Forests can be either natural endowment, or social products, but they have different responses to socio-economic environments. The net change in forests is determined by the total effects.

Joining in the current debate and concerns regarding deforestation in developing countries, an attempt is made to formulate an integrated theoretical framework of the deforestation and forest transition and to provide empirical evidence from China. The forecasts and policy suggestions to be presented are argued to be relevant not only to China but also to other countries.

2 Framework of Deforestation and Forest Transition

The theoretical framework of forest land change, which is extended from the model by von Thunen (1875), is illustrated by Figure 1. Land is used for the option which creates the highest land rent in a competitive land market. Therefore, the land use option and forest management method are determined by the land quality and socio-economic environment. Land quality is a broad concept here, referring not only to soil, steepness, incidence of rocks, sources of water and exposure to wind and sun, but also to distance and types of roads to market and habitation, etc. The socio-economic environment refers to the output and input prices, and institutions. The input and output prices can be measured on-site and in a market. Prices may vary greatly when transportation costs are significant.

2.1 Land Use for Agriculture versus Forestry

The land rent for forestry or any other land use is determined by the output prices, the input costs and the land quality. For simplicity, agriculture is considered as the only other land use option. If we use (p_a, w_a) and (p_f, w_f) to represent the set of output price and input cost by agriculture and forestry respectively, the land rent for agriculture and forestry with land quality q will be $\pi_a(p_a, w_a, q)$ and $\pi_f(p_f, w_f, q)$. If $\pi_a(p_a, w_a, q) > \pi_f(p_f, w_f, q)$, the land will be allocated to agricultural use. Otherwise, the land will be used for forestry. For instance, the land to the left of A in Figure 1 should be allocat-

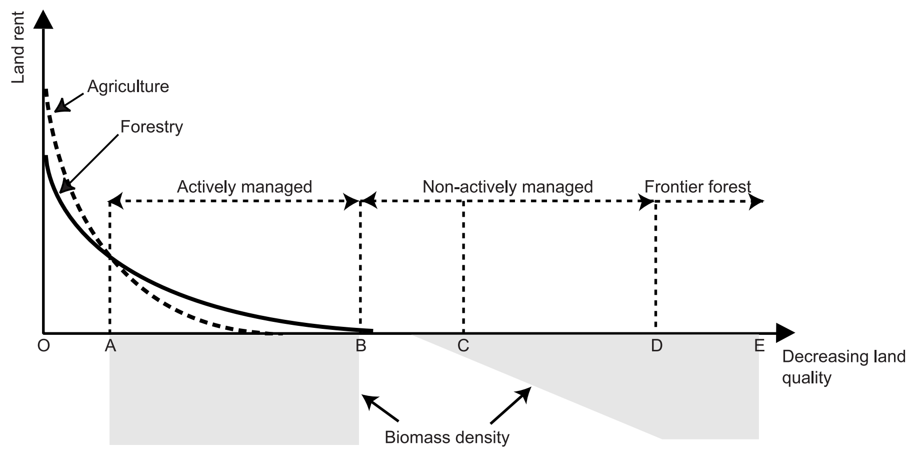


Figure 1: Land use for agriculture and forestry by land quality

ed to agricultural use, and the land to the right of A should be used for forestry. On the boundary, the rents for agriculture and forestry are equal.

Point A in Figure 1 shifts when on-site output or input prices for agriculture and forestry and land quality change. For simplification, we just consider the changes in input and output prices and do not consider land quality change that may derive from road expansion, soil degradation, etc. Graphically, if prices for agricultural goods rise (or input price decreases), the curve of the agricultural rent will shift to the right, and some of the forestry land will be devoted to agriculture. Alternatively, if the prices of forest products rise (or its input price decreases), some of agricultural land will be devoted to forestry.

Mathematically, to understand the effects of the change in forest product prices on the shift of the forest-agriculture frontier, the total derivative of the equation $\pi_a(p_a, w_a, q^*) - \pi_f(p_f, w_f, q^*) = 0$ (q^* refers to the boundary land where rent created from forestry and agriculture is equal) with respective to q^* and p_f is: $(\partial\pi_a/\partial q^*) \times dq^* - (\partial\pi_f/\partial q^*) \times dq^* - (\partial\pi_f/\partial p_f) \times dp_f = 0$. Therefore, $(dq^*/dp_f) = (\partial\pi_f/\partial p_f) / [(\partial\pi_a/\partial q^*) - (\partial\pi_f/\partial q^*)]$. As long as the higher quality land is used for agriculture, $[(\partial\pi_a/\partial q^*) - (\partial\pi_f/\partial q^*)]$ will be positive, so (dq^*/dp_f) is also positive since $(\partial\pi_f/\partial p_f)$ is positive. The new equilibrium point q^* will therefore move to better land quality q^{**} when prices of forest products rise, thus some of the higher quality land currently used for agriculture will be devoted to forestry $(q^{**} > q^*)$. By the same procedure, it is possible to derive the land use shift between forestry and agriculture in response to the changes of agricultural products and the inputs in forestry and agriculture as

$$\text{Forestry land} = A_f(\underset{-}{p_a}, \underset{+}{w_a}, \underset{+}{p_f}, \underset{-}{w_f}) \qquad [1]$$

It must be emphasized that land conversion is not costless and the cost is often sunk. In reality, land use conversion becomes much less flexible when the cost associated with conversion is considered, while land modification, referring to change within one category, e.g. among different agricultural crops, is quite flexible. Land use conversion from forestry to agriculture is more likely to happen when trees are grown to (or quite close to) an economically mature age. The capital in silviculture is sunk and cannot be recovered (even partly) if the trees are too young. Land conversion from forestry to agriculture requires significant investment. It may take years to cut down the trees, remove stumps and stones, erect buildings and fences, to develop large-scale irrigation and drainage system, and to expand the initial clearings into productive farms. Most of such investment is also sunk. If the expected outcome (the prices and costs) does not differ greatly from the reality, the land is likely to remain in agricultural use.

Forest land conversion to agriculture and other uses might be significant during the early stage of economic development, but it would not be critical with respect to the total land area available for forestry. The more critical problems are: (1) the stagnant timber price, poor credit markets, risk aversion, and poorly developed institutions do not justify forest investment for the logged-over land; (2) forestry may be unprofitable on a quite large area abandoned by other land uses due to soil degradation and other socio-economic reasons. That is why deforestation is much faster than the expansion of agricultural land in most developing countries.

2.2 Management of Forest Land

FAO (1995a) defined forest land under active management as “forest and other woody land that is managed according to a professionally prepared plan or is otherwise under a recognized form of management applied regularly over a long period (five years or more)". Land will be under active forest management if $0< \pi_f(p_f,w_f,q)$ and $\pi_f(p_f,w_f,q) > \pi_a(p_a,w_a,q)$. In Figure 1, only the land to the left of B is under active forest management.

The amount of investment and the length of rotation, the decision variables in forest management, are functions of the land quality, output and input prices. To calculate the optimal investment and rotation, the Faustmann model can be applied

$$\pi_f(q) = \max_{T,E} r\{ \int_0^T g(t, E; \Psi, q)\, e^{-rt}\, dt + p(Q,q)Q(T, E; p,w,q)e^{-rT} - w(q)E\} / [(1- e^{-rT})] \quad [2]$$

where, $\pi_f(q)$ is annual land rent created by forestry for land quality class q; $p(Q, q)$ is on-site stumpage price, which is a function of the status of forest (Q), e.g. biomass density and tree species and land quality such as steepness and distance from the market under given market price; w is on-site unit cost of silviculture, which is a function of the market costs (both materials and labor) and the distance from the labor supply, the likely labor market and materials supply, r is the capital cost or simply interest rate; T and E are length of rotation and on-site units of silviculture efforts; g is annual accumulative *in situ* value of forest at age t. ψ represents factors such as population, income and economic structure, which affect the demand for *in situ* forest products (Park et al. 1998).

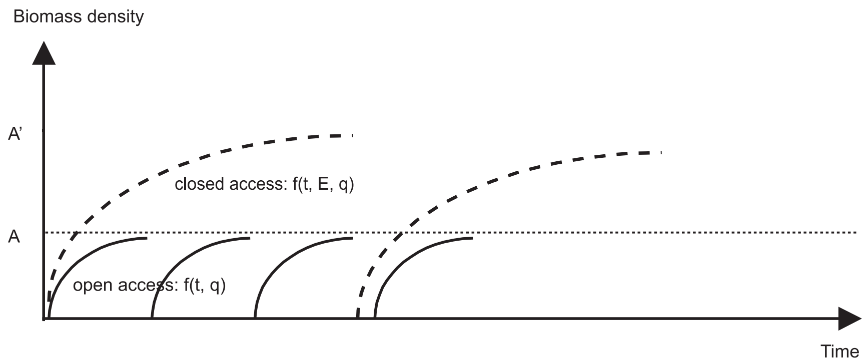
The optimal solution of rotation T and silviculture efforts E can be obtained from the first order maximizing conditions. An extreme case is that the optimal solution is $T\rightarrow\infty$. This means that the forest management is undertaken for only environmental purposes: if forest does not exist, trees will be planted; if the forest is already existing, logging will not be undertaken, e.g. natural reserves and public parks. However, a more common solution could not be $T\rightarrow\infty$, i.e. joint management of timber production and environmental services could be more common in active forest management regimes. Clear cutting is gradually regulated, while its alternative, selective cutting, is more accepted due to appreciation of environmental value. It means the new rota- tion always start from a certain age of trees.

Non-Active Forest Management

The unexploitable forests, which are located to the right of D in Figure 1, means that the stumpage price is zero, $p(Q, q) = 0$. Of course, land value for forest management is also zero. Since the forests already exist, their value is not related to soil productivity, but is closely related to the status of the forests (Q), depicting species, the growing stock of the forests, the distance and the accessibility to the market, and harvesting and transport technology.

Except for the unexploitable forests, all forestry land is assumed to be under active management based on traditional production economics which consider no transaction costs. Because forest regeneration can be achieved naturally, without any or very minor on-site silviculture efforts for most logged-over land $\partial Q(T, E; q)/\partial T>0$ when $E\approx 0$, the $p(Q, q)$ shall become positive when Q reaches a certain level, e.g. the original level after a certain years. Since it is theoretically possible for the forest to recover to its original biomass density, positive rent is possible, and active management has value.

However, much land world-wide is today not under active management. This is particularly so in developing countries.



Note: If E = 0, the early growth function of closed access is the same as open access before time t.

Figure 2: Forest biomass density growth under open access and closed access

The land not under active management is often interpreted by economists to be the result of open access. On the other hand, while the change from open access to closed access can create Pareto efficiency, it is difficult to understand why open access is so common in developing countries. The problem lies in that traditional production economics does not consider transaction costs. The transaction costs associated with land ownership change includes *ex ante* and *ex post* elements (Mattews 1986). It is not costless to move from open access to closed access.

Increasing timber prices or decreasing extraction costs – due to road construction or improved logging or transportation technology – will make more remote forests increasingly exploitable, shifting the forest frontier (Point D in Figure 1) and probably some secondary forests (Point C) to the right. Frontier forests on a large scale are located in remote and less populated regions. Since most of these forests are owned by the state or are in open access, any change in the frontier will greatly depend on public policies in road expansion, population settlement and logging regulations.

Between these two extremes, there is substantial forest or forestry land that is under non-active management, the area between B and D in Figure 1. Because the exclusion cost is the most important reason that makes forest management unjustified, the shifts of Point B and C in Figure 1 are highly sensitive to general socio-economic, political and institutional conditions. Figure 2 shows the different biomass growth under open and closed access.

The Cost of Exercising Ownership

Here the *ex ante* costs of transaction are not discussed, as these are associated with defining and transforming property rights. The *ex post* costs of transaction are more important regarding trees and forested land, but these are often ignored by academic studies. The common situation is that the land is given ownership, even legal rights either by the state, the community, private persons or organization, but the owners fail to exercise rights when the gains from implementing their exclusion rights are deemed insufficient. Thus the land is left in public domain, in open or quasi-open access.

The costs of ownership not only include the cost of obtaining titled or recognized rights, but also the cost of protecting existing rights. If exercising existing rights is too costly, the ownership becomes nominal: the legal rights are retained but not the economic rights (for more about the difference between legal rights and economic rights see Barzel 1997). Therefore, an answer to open access could be the high *ex ante* and *ex post* costs associated with transactions where the land is originally not owned, or with *ex post* "exclusion costs" associated with transaction where the land is already owned. In other words, the actual land value is the profit calculated by the traditional production economics minus the transaction costs of obtaining and protecting the land and forests.

When the exclusion cost is added to the production function, Equation [2] is transferred as follows

$$\pi_f(q) = \max_{\boldsymbol{T},\boldsymbol{E}} r\{ \int_0^{\boldsymbol{T}} g(t, E;\ \Psi, q)\, e^{-rt}\, dt + p(Q, q)\, Q(T, E; p, w, q) e^{-rT} - w(q)\, E - \int_0^{\boldsymbol{T}} \mu(t, E;\ \Phi, q)\, e^{-rt}\, dt\,)\}/[(1-e^{-rT})] \qquad [3]$$

where μ is the annual protection costs for forests at age t, which is a function of the status of forests, the institutions (Φ), land identity, and perhaps other socio-economic variables. Now it is much easier to understand why quite a large land area has zero land rent, and active forest management is not justified. In this case, the optimal solution is $E = 0$, and T is the time when the biomass density rises to justify extraction. The μ is also a decision variable. The owners must make a trade-off between a possibility of losing their economic rights and investment in protecting their rights. For simplicity, let us unrealistically keep it as cost of protecting the full economic rights with no possibility of loss.

To emphasize the importance of exclusion costs, let us use China as an example to show how big the magnitude of the costs can be in association with property right protection. According to officially documented statistics from the Ministry of Forestry (1992), there were one million people employed in preventing illegal access to forests. Of these more than one third were full-time jobs in the early 1990s. There were another 200 000 officials whose duties were associated with designing and implementing regulations, and assisting disputed settlements concerning forest property rights. These figures demonstrate the considerable magnitude of the costs of protection. Forest management has to consider these costs. Even so, illegal logging is still rampant in China due to the characteristics of the forests such as easy access, no clear maturity, and traditional conventions, norms and laws as well as wide-spread poverty.

Illegal extraction in forests, particularly in common forests (not to be confused with open access forest), is often looked upon as being less criminal than in agriculture because, historically, trees are "wilder" than agricultural crops. Trees are often viewed to be in the public domain, at least to some extent. On the other hand, if stealing a tree worth one-month's wage is without much risk of being caught and with no serious penalty if caught, illegal logging will remain difficult to prevent. It is not surprising, therefore that Poore et al. (1989) conclude that non-active forest management is so common and sustainable forest management is so rare in the tropics.

The Cost of Exercising Exchange

As discussed above, the costs of exercising ownership can be interpreted as part of transaction costs. Now we turn to another closely related transaction cost: the cost of exercising exchange through the market. This was interpreted by Coase (1937) as a more fundamental reason for the emergence of firms. He defined the transaction cost as "the cost of using price mechanisms", "the cost of carrying out a transaction by means of an exchange on the open market" or simply "marketing costs". Coase (1960) further explained transaction costs as "to discover who it is that one wishes to deal with, to inform people that one wishes to deal on what terms, to conduct negotiations leading up to a bargain, to draw up contract, to undertake the inspection … and so on".

The Faustmann model clearly does not include the marketing cost of the output – neither the cost of organizing the production, nor the "purchasing" cost of input factors, such as labor and capital. This may not be important if such costs are relatively small compared with the value in exchange. However, these costs are not small due to the characteristics of forest products (or stumpage) and the status of market instruments in the developing countries. Even in an advanced economy, the cost of capital, the simplest product, is usually more than 5%, the difference between interest rates of deposit in and loan from a bank. The long persistence of self-sufficiency economies in developing countries is largely consequent upon the cost of exchange through the market.

2.3 Causes for Shifts in Land Use and Management

Point A in Figure 1 shall shift when on-site output or input prices for agriculture and forestry – or land quality – change. The onsite price change is often difficult to observe. More generally, the land use change may be considered to have resulted from the changes associated with population, infrastructure, technology, or institutions. These factors are not addressed separately, but discussed in the framework of population and institutional changes.

The Role of Population Change

In the short term, it is assumed that population settlement remains static. Point A in Figure 1 could be very sensitive to the change of the relative market price of timber and other goods that are largely based on land. During the early stage of economic development of a country with substantial natural forest growing stock, the elasticity of timber price to population growth is likely to be less than the elasticity of food price to population growth. Consequently, agricultural expansion is likely, and Point A in Figure 1 usually shifts to the right.

The above is based on static human settlement, but populations are always seeking for cheap resources, including land and forest resources. Population growth changes the land-labor ratio. Consequently, changes in the relative prices of land and labor lead to an increase in the value of inferior land. With respect to forest resources, the decline in the forest-labor ratio increases the relative value of forests and decreases the value of labor. Thus increasingly inferior forest becomes valuable and labor spreads out to seek its higher value. In other words, when population migration is less costly than transporting the resources, population will move to locations close to the resources. The population movement can occur either as a slow spread of population, or as big new settlement projects which are rapidly established. This process will continue as long as any virgin land and frontier forests remain. Historically, population migration plays a much more important role in forest change than the local growth of population.

The general path on forest change in the context of population change is, therefore, as follows: First, as the population grows and the economy develops, the speed with which A in Figure 1 shifts to the right for agricultural expansion, and the speed with which D shifts to the right for timber extraction from frontier forest is faster than the movement of B to the right. The area between B and D is largely bareland, open forest and shrubs, and non-actively managed forest land. Whenever a large forest area or other land resources are not inhabited and used, population migrations into these areas are likely to occur. Therefore, deforestation could occur for a quite long period of time. When Point D approaches E, pushing D to the right is difficult because of increasing marginal costs. The speed with which B moves to the right increases as price increases. Finally, forest expansion becomes dominant. At this time, large population movements are mostly characterized by urbanization. Forest cover would cease to decrease, remain stable, or perhaps even begin to increase.

The Role of Institutions

The impacts of institutions on economic performance have been acknowledged since John Stuart Mill, Adam Smith and Karl Marx. Recently, institutions have received great attention by institutional economics that include economics of transaction costs and the economics of property rights (see e.g. Coase 1937, 1960; Lewis 1955; Kuznets 1966, 1973; Stigler 1966; Alchian and Demstz 1972; North and Thomas 1973; Dahlman 1979; Cheung 1983; North 1981, 1990; Williamson 1975, 1985; Barzel 1997). Using similar arguments that apply to more general economic performance, it is hardly controversial that changing institutions may have great influence on land use. It is still argued as to what kind of causality relationship exists between economic performance, institutions and technology. It seems plausible that they are interactive.

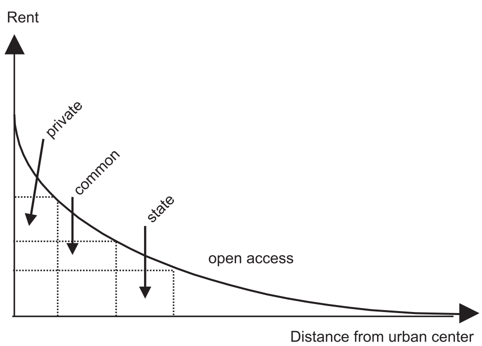


Figure 3: The rent gradient and property regime *(Bromley 1991)*

In the long-term, institutional evolution may be greatly affected by the process of socio-economic development. Along with the increase of scarcity, the gains from transformation from open access to closed access will gradually exceed the costs and hence have an effect on institutional arrangements. Open access may change into closed access. In addition, the scarcity might justify transfers of ownership, for example state forests might be transferred to community ownership. These again may be transferred into private ownership. That is why we may find much less community owned land in the developed than in the developing countries. However, increasing scarcity of environmental goods might again justify some transactions from private forest land into public domain. The general pattern of land property regimes is illustrated in Figure 3.

Institutional changes, either in property right institutions or market (non-market) institutions, may not always evolve efficiently and instantly. Institutional rigidity and inertia may persist for a considerable period of time. Inertia may prevent institutional adaptations to the environmental changes as well as causing institutions to be inefficient. Information and knowledge concerning alternative institutions are always limited, the judgment and decision making in choosing therefore vary from society to society. In addition, institutional arrangements, particularly in the short term, are to a large extent the product of public choice under the balance of power among different interest groups. Significant differences are observable in the institutions of countries with similar environments.

Following the insights of transaction cost economics, the characteristics (as immobility, long-waited maturity, difficulty in delineating property rights) of relatively large magnitude of the transaction costs compared to production costs in forest management, make forestry more sensitive to institutional arrangements. In developing countries agriculture, which is more technology oriented than silviculture, has reached levels which are not too far behind the level in developed countries. In forestry, there is much more poor management in developing than developed countries. Even silvicultural technology is in general still primitive in developing countries compared with developed ones. The difference in the performance of forest management in developing countries compared with developed ones is largely due to institutional differences.

3 History of Deforestation Process

China has a good record of information regarding forest and land use changes. Very detailed records have been kept on vegetation, flora, fauna, climate and agriculture development for more than 3000 years. However, until the 1950s, there was little material in the English language, except for some reports contributed by professional plant hunters from Europe and America in the late 19th and early 20th centuries, and by a few Chinese scholars who were educated abroad. According to Murphey (1983), Jean Baptiste du Halde's description of the Empire of China, published in Paris in 1735 and in English in London in 1738, could be the earliest work for westerners. Perkins (1969) explored agricultural land development from 1368 to 1968. Shaw (1914) also could also be among the earliest commentators on China's forests and timber supply. Murphey (1983) focused on deforestation in the 19th and the first half of the 20th century. Menzies (1994) described the historical pattern of land use and deforestation in China by referencing ancient literature.

If the current territory of China is divided by a diagonal line from the northeast to the southwest, the original vegetation cover can be classified into three categories: Forest land dominated the area with an extensive and dense forest cover of over 70–90% to the right of the diagonal; grassland and forest with 20–30% forest cover dominated in the transition zone, along the diagonal line; and as the third category desert and bareland dominated with less than 5% scattered forest to the left of the diagonal. The types of forests varied from boreal forest in the northeast, temperate deciduous broadleaf in the north, and mixed deciduous and evergreen broadleaf forest in the south, with tropical forests in the southernmost region of China. Thus, about half of the land was originally covered by forest. Liu and Wang (1989) estimated that in 2700 BC there were six provinces with more than 90% forest cover and 14 provinces with more than 50%.

3.1 Loess Plateau and Guangzhong Region

Significant deforestation began at least as early as 3000 BC in the Loess Plateau Area, the place of the origin of the Chinese civilization. A temporal process of deforestation started from the heartland of the Guangzhong region, currently Gansu and

Shaanxi Provinces, at the junction of the Wei and Yellow Huang Rivers. According to archeological records, the population was dense in this area around 3000 BC. The original status of the vegetation was and is a subject of much debate between advocates of the forested vegetation view (Teng 1947; Wen and He 1979; Wang and Sheng 1994) and the non-woody vegetation view (Handel-Mazetti 1931). Based on information contained in the Book of Odes (*Shi Jing*) and the Classic of Mountains and Rivers (*Shan Hai Jing*), among other sources, it is more widely accepted in China that the forest was dominant before human intervention. Because this site is located in an ecological transition zone from moist to semi-arid and arid climate, it would more likely vary between forest-dominated and grass-dominated vegetation, rather than arid deserts. Menzies (1994) considers that the image of the pristine landscape of northern China was neither of dense forest nor of barren steppe, but rather of a mosaic of vegetation: riparian forest followed the courses of rivers, with rather sparse deciduous woodland and brush on the mountains and denser deciduous forest on the foothills.

It is widely recognized that the natural environment of the Loess Plateau Area was greatly damaged around 1000–500 BC. There are interesting records which concern the Wei and Yellow Rivers in this respect. According to *Wei Feng* in *Shi Jin*, the rivers nearly 3000 years ago were very clear, indicating no soil erosion. The rivers may still have been occasionally clear 2500 years ago. Thereafter the rivers were always yellow. The Yellow River, probably named during the period 320–311 BC, indicates the acute soil erosion and high silt loads at that time. It should be noted that climate change has been suggested as the cause of this deforestation. However, the fragile environment and climate change only made the recovery of vegetation more difficult. It is logical to assume that the causes of deforestation and degradation are to be found in agricultural expansions that began around 3000 BC and reached their climax around 1000 BC, following logging as the population grew and spread.

3.2 North China

As the environment deteriorated, the Loess Plateau region shrank and the population with its economic and cultural centers moved eastward along the Yellow River to the current Shanxi, Henan and Shandong provinces. Rich forests covered the Tai Mountains region, consisting of several high mountains: Tai, Lu, Yi, Men, Daze and Kunlun among others. According to ancient literature, the vegetation was dominated by natural forest and grassland 3200–3000 years ago (Wang and Sheng 1994). This view is supported by many notations on the activities of large wild animals, including tiger, elephant, rhinoceros and others recorded in the *Meng Zi-Teng Wen Gong, Shi Ji-Zhou Ben Ji, Lu Shi Chun Qiu* and other classical literature.

According to the *Meng Zi-Gao Zi,* land reclamation had begun at the time of the Zhou Dynasty (1100–256 BC) during which significant areas of natural forest were logged and transported to nearby areas, which were the most civilized and populated in China at that time. The population density was still low, however, and people mainly resided in the lowlands. By 500 BC, the forest had been logged extensively, but much forest still remained in the middle of mountains due to difficult accessibility. The forests, in general, were seriously damaged during the period 500–0 BC. In the following years, logging and agricultural expansion steadily progressed to the mountainous range and spread southward and northward. The agents of deforestation were mainly logging, followed by pastoral husbandry and steadily increasing reclamation towards the marginal area.

The population continued to move northward and the capital was relocated in Beijing during the Yuan Dynasty (1271–1368) in 1297. Rich forest grew on the Yan Mountains. This site was located in a socio-economic and political transition zone, varying from developed, permanent agricultural area in the south (North China Plains) inhabited by the Han Chinese, to the pastoral agricultural area in the north, inhabited by minorities. This location, according to some research, was still dominated by forests and grass land and mainly inhabited by nomads since only marginal reclamation was occasionally carried out by Han prior to the Yuan Dynasty. In the beginning of the Yuan Dynasty, this area was listed as a hunting preserve of the emperors and was well protected. The growing population, together with an increasingly significant economy, promoted the demand for food, fuelwood and timber. The whole process of deforestation was fulfilled during the Yuan Dynasty, Ming Dynasty (1368–1644) and Qing Dynasty (1616–1911). The driving forces were intensive hunting, repeated logging for timber and fuelwood, followed by pastoral husbandry and cultivation. Fuelwood collecti- on is assumed to be a critical factor in deforestation, since fuelwood collection, regardless of the size of the trees, may be repeated too frequently and intensively. In the beginning of this century, no large area of forests remained in this region.

3.3 South and Southeast China

During the late Song Dynasty (960–1279), southern China was experiencing a rapid population growth and migration from the north when northern China was occupied by the Mongolians. The capital was transferred to Hangzhou in the current Zhejiang Province in 1127. A significant area of forest was converted into agricultural land during the following decades. Because of its mountainous landscape and favorable climate, southern China still had an abundance of virgin and secondary forests during the Song and the Ming Dynasties and the early part of the Qing Dynasty. The most significant loss of forest occurred during the late Qing Dynasty, particularly during the war of Taiping Rebellion (1851–64).

The population was not limited to the mainland, a large number of the people immigrated across the Qiongzhou strait to Hainan Island during the Song and Yuan Dynasties. From the Han Dynasty (206 BC–220 AD) to the Tan Dynasty (618–907), this island was populated along the southeast coast mostly by the minority Li. Shifting cultivation was in fact firstly widely carried out along the southeastern seashore where the Li first settled. They then retreated steadily to the central mountains after the Song Dynasty. At that time, the shifting cultivation was gradually replaced by semi-permanent cultivation, followed by permanent cultivation in the northwest and southeast. With the introduction of new tools, the areas along the seashore settled by the Han, who had come there from the mainland, steadily came under permanent cultivation. Before the Song and Ming Dynasties, large areas of virgin forests still existed since the forest was mainly used as the source of non-wood forest products: berry collecting, hunting and limited harvesting for household use. Around the 16th century, timber extraction for industry and direct supply to be market began. At the beginning of the 20th century Hainan was threatened by a lack of timber (Pen 1922).

Due to the difficult accessibility to the center of Hainan Island, there was still large areas of tropical forest in the middle of the mountains at the early part of the 20th century. The most significant timber extraction from the rain forest took place during the 20th century, particularly from the 1950s to the 1980s. Most of the tropical crops, particularly the rubber tree were introduced around 1900, and have promoted significant agricultural expansion, especially during the last 50 years.

3.4 Southwest and Northeast China

The southwest parts of Sichun and Yunnan provinces still had a lot of natural forests remaining at the beginning of the 20th century. The most significant deforestation occurred during the last 50 years. Currently, only Tibet and some parts of Yunnan, for instance Xishunbanan, still have any remains of virgin forests.

Northeast China had large areas of virgin forest at the latter part of the 19th century. The Changbai Mountains region was almost pristine land before the Qing Dynasty, and it was still well preserved by the emporers as a traditional Manchurian base and imperial hunting ground in the early Qing Dynasty. Han (Chinese) settlements began to spread northeastward beyond the Great Wall on large scale only after 1870 when the Qing authority weakened and the population pressure in North China increased. The earliest Han immigrants, however, first arrived on the Liaodong Plains, south of Liaoning Province, which is the southwest to the Changbai Mountains. The population was still small relative to the large territory. Only marginal natural forest was logged by the end of the 19th century. Russian railway construction in the late 19th century and the Japanese takeover in northeast China in the early 20th century promoted significant deforestation in the Changbai Mountains. It is estimated that about 100 mill. m^3 of timber had been transported out and 6 mill. ha of forests was logged, accounting for approximately half of the total area (Liu and Sun 1985).

The remaining forests in the Changbai Mountains region were further logged after 1949 when the People's Republic of China was founded. Over 30 forest bureaus were set up after 1949 with the intention to log the forests. About 10 mill. m^3 of industrial logs flowed out of the region and huge amounts of timber were annually consumed locally (Ministry of Forestry 1987). From the 1950s to the 1980s, the logged area amounted to 1.5 mill. ha. It is estimated that by the end of the 20th century there will be no accessible mature natural forest left. Large areas of forest land were converted into agricultural use to serve the growing population, which has more than doubled during the last 50 years. Soil erosion is becoming very serious. For example, in the seven counties located east of Liaoning Province, more than 0.2 mill. ha of cultivated land have had to be abandoned due to soil erosion.

Heilongjiang Province, located to the northeast of the Changbai mountains, has

Table 1: Forest resources decline in Heilongjiang Province

Year	Forested area (mill. ha)	Growing stock (billion m^3)	Forest cover rate (%)	Notes
1900	32	3.6	70	Qing Dynasty
1931	24	2.5	53	Japanese invasion of Manchuria
1945	20	2.0	44	End of Japanese occupation
1980	16	1.5	36	
1985	15	1.3	34	

(Heilongjiang General Bureau of Forestry 1987)

a shorter history of deforestation (see Table 1). One of the most important forest regions is the Xiaoxinganling range that is bordered by the Heilongjiang River in the north, by the Songhuajiang River in the south, the Daxinganling range in the northwest and a large plain in the southwest. Logging was started during the Japanese occupation, but only along the railway from Harbin to Jiamushi. From 1950 to the mid-1980s, a total of 24 state-owned logging enterprises were set up, and about 0.3 bill. m^3 of logs were produced, approximately 1/7 of China's total industrial timber production during that period.

Most of the state-owned logging enterprises are now short of mature forest resources in Heilongjiang Province. From 1950 to 1978 in the Yichun prefecture alone, in the heart of Xiaoxinanliang, the growing stock decreased from 4146 mill. m^3 to 2414 mill. m^3, the share of coniferous forest in total inventory decreased from 68.5 % to 51%, and the proportion of Korean pine in the total from 13% to 6.4% (Ministry of Forestry 1987). In addition, agricultural clearances claimed much of the forest land. For example, in Heihe alone, the area under agriculture increased by 35 000 ha from 1962 to 1980.

3.5 General Pattern of Deforestation

To summarize, China's deforestation started in the Loess Plateau Area, moving eastward along the Yellow River to the current Shanxi, Henan and Shandong Provinces, then spread northward to the current Hebei and Beijing regions, and finally moved beyond the Great Wall to northeast China. Meanwhile, the population moved southward to southern China, even across the sea to Hainan Island. In general, the plains and locations along major rivers were usually occupied and cultivated first, then progressed to low hilly regions and finally to mountainous ranges. Table 2, using six regions as an example illustrates the popula-

Table 2: Deforestation in six selected sites

	Loess Plateau area	Tai mountains	Yan mountains	Hainan Island	Changbai mountains	Xiaoxinganling area
Area (1 000 km^2)	300	120	120	34	180	120
Length and period of deforestation	4000 years (3500BC–500BC)	1000 years (1000BC–0)	600 years (1300–1900)	400 years (1580–1980)	100 years (1900–2000)	40 years (1950–1990)
The lowest forest cover rate	10%	10%	10%	15%	50%	50%
Current population density (persons/km^2)	100	500	150	200	100	30
Main agents of deforestation	logging, subsistence agriculture, climate change	logging; subsistence agriculture	logging; subsistence agriculture	logging; subsistence and tropical crops cultivation	logging; cultivation	logging; cultivation
Underlying causes	population growth	population growth	population growth	population growth; timber demand outside the region	timber demand outside the region; population growth	timber demand outside the region; population growth

tion movement, deforestation, and agents and underlying causes.

Over these thousands of years, there has been a cycle of deforestation, mild recovery, and more severe deforestation (Liao 1987). In general, intensive logging in the frontier forests and better management of the secondary forests coexisted at the beginning of each dynasty because relatively greater population growth and the stronger economy demanded more agricultural land and timber. Better management was also secured by a more stable political regime and a strong government. Rampant forest destruction, due to wars, conflicts and weak government and institutions, was frequently found at the end of each dynasty.

The demand for agricultural land and timber following human settlement are clearly the primary causes of forest loss. However, the rate of agricultural land expansion is much lower than that of the population, and deforestation is much faster than the agricultural land expansion (see Figure 4). As early as the Tang and Yao era (about 2500 BC), shifting cultivation was extensively carried out and continued for one thousand years during the Xia and Shan

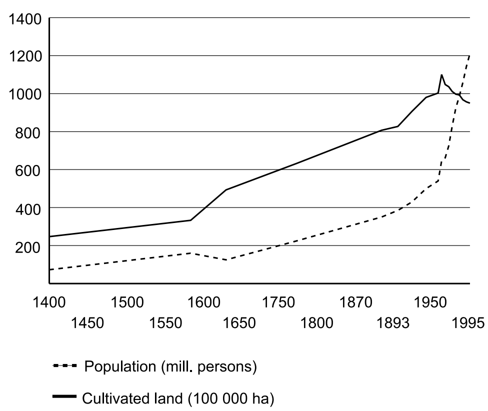


Figure 4: Changes in population and cultivated land area in China, 1400-1995 *(Perkins 1969; Wang 1992; Ministry of Agriculture 1950–1995)*

Dynasties (2100 BC–1100 BC). During the early Han Dynasty (206 BC–220 AD), the Chinese began a systematic land reclamation and irrigation schemes.

During the 20th century, the area of agricultural land has not significantly increased, but the loss of forests continues. A large part of the loss is not because the land is constantly occupied by other uses, but rather because it is abandoned and not converted to active forest management. This applies to the logged-over forest land.

4 From Deforestation to Forest Transition

Data concerning China's forest resources was published in the China Yearbook in 1943 and on at least ten other occasions before the first national forest inventory (1973–1976). All the data, basically relying on the data of 1943, stated that the forest cover rate ranged from 5% to 8%; the 8% is more often cited. These figures, however, are misleading. The mistakes resulted from both incorrect estimates and varying definitions, such as definition of forest, the territory of China, etc. Unfortunately, many public officials and academics, both domestic and international, have used this data as a point of reference (Chu 1988). Thus, this 1943 forest area became the most widely recognized benchmark when the People's Republic of China was founded in 1949.

When the first national inventory was published, the forest cover rate was given as 12.7%. It seemed that forest resources had significantly increased over the 8% figure given for 1949. In fact, it is reasonable to believe that the 1949 forest area proportion was about 15% assuming the same definition of forests. Be that as it may, the process of deforestation continued during the first 30 years of the People's Republic

Table 3: Land use conversion between forestry and other land uses in China, 1980–1986 and 1986–1992

	Into forest land (mill. ha) (1)		From forest land (mill. ha) (2)		Net forested area change (mill. ha) (3)=(1)–(2)	
	1980–1986	1986–1992	1980–1986	1986–1992	1980–1986	1986–1992
Open forest	6.7	5.2	7.8	3.5	–1.1	1.7
Bush and shrub	1.9	1.1	1.5	0.4	0.4	0.8
New planted forest	3.2	3.5	2.0	1.5	1.2	2.0
Bareland	10.1	6.1	8.2	3.6	1.9	3.5
Other land use[1]	5.3	3.3	3.8	2.0	1.5	1.3
Total	27.2	19.2	23.3	11.0	3.9	9.3

(Ministry of Forestry 1989; 1995)

Note[1]: Other land uses might not necessarily mean non-forested land. In China's statistical system, the definition of forestry land and forested land refer to the potential use and the sectoral ministry who manages the land. For instance, some forested land owned by agricultural farms is likely to be listed as agricultural land. Therefore, the real conversion between forested land and other land uses is much smaller that the figures show.

of China. Logging in northeast and southwest China may have had social and economic benefits, but the radical deforestation during the Great-Leap-Forward in 1958 and the Cultural Revolution from 1966–1976 was a complete abuse of natural resources.

However, since the 1970s, China seems to have embarked on a road to forest transition. The analysis here is mainly based on the four national forest inventories conducted during 1973–1976, 1977–1981, 1984–1988 and 1989–1993. FAO (1995b) assumes that the reliability class is 1 for the state estimates and 2 for the change assessment (range from best = 1 to worst = 3). The present study divides China's territory into five regions: Northwest, North, Northeast, South-Southeast, and Southwest (see Map 1). The land use in these five regions is illustrated in Figure 5. From the figures, some general conclusions can be drawn: the turn from contracting to expanding forest area in the Northwest of China occurred during the late 1970s; in the North and South-Southeast the turn occurred during the early 1980s; in the Northeast and Southwest the transition started during the late 1980s and early 1990s.

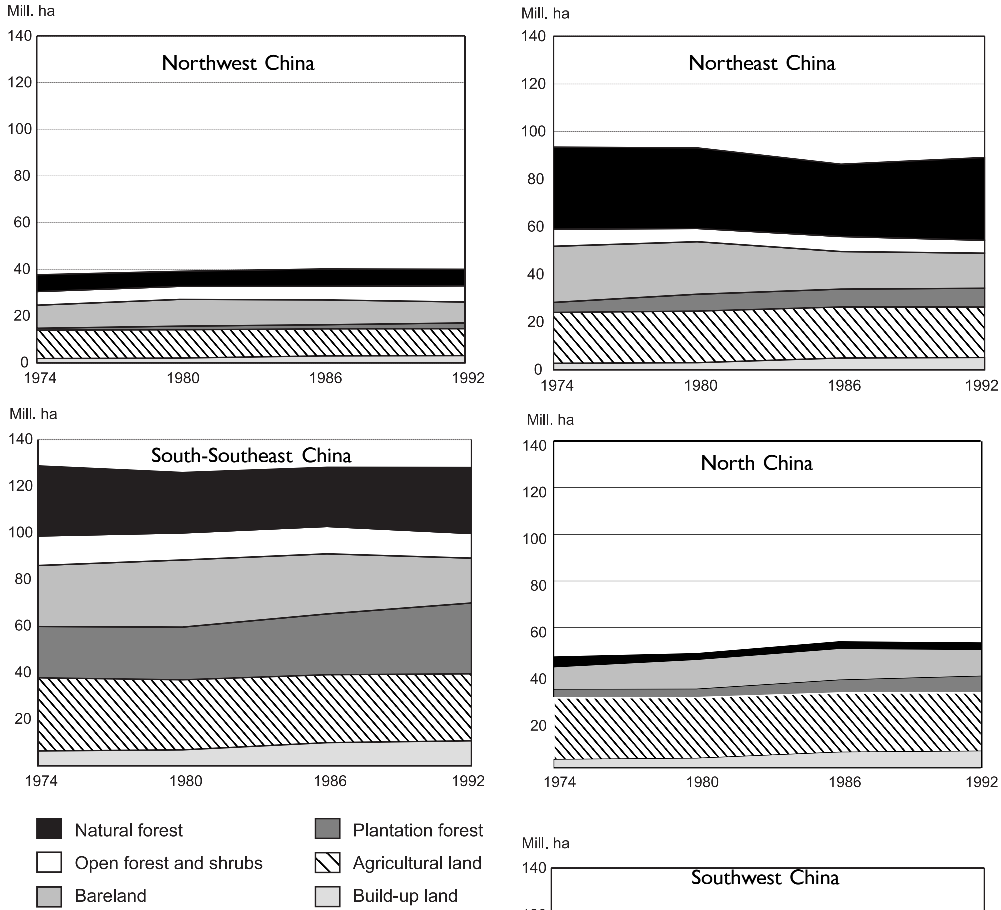
Table 3 illustrates in more detail the on-site land conversion among different categories. The estimates are based on 200 000 repeated on-site observations. In general, the shifts of land use from one category to another have become less significant. The increase in forested area was more likely deriving from open forest, shrubs and bareland. Therefore the increase of the forest land area does not necessary mean a conversion of other productive land use cate-

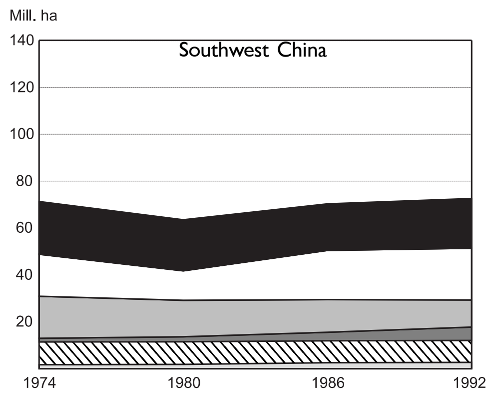
Map 1: China's regions and provinces

gories into forest land. The conflicts between land use are often overestimated.

Scarcity of timber and Environmental Goods

As discussed in the theoretical section, a scarcity of timber makes more remote forests exploitable, while the scarcity of land and forest resources compared with population causes populations to move. However, as was indicated earlier, the relative scarcity of timber also justifies active forest management. Hyde et al. (1993) and Hyde and Seve (1996) had an intensive discussion on the response to timber scarcity





Note: The provinces for each region refer to Map 1. The bareland only includes the technically forestable land, so the sum of land is possibly not equal to total land area; the build-up area includes urban and industrial areas, roads, etc; some discrepancies are due to statistical problems, particularly in Southwest, where the boundary of Tibet was not quite clear.

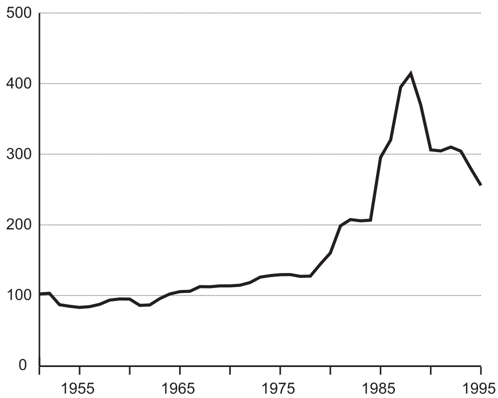
Figure 5: Major land uses in China by regions from 1970s to 1990s *(Ministry of Forestry 1978, 1982, 1988, 1995; China's Statistical Bureau 1975–1996)*

in terms of combating deforestation and argued that deforestation has an economic limit that precedes its physical limit. Figure 6 shows the scarcity of forest resources as measured by the deflated timber price. Prior to the late 1970s, timber price was tightly controlled by government. Price might not be good as a measure of scarcity of timber, as the price did not show a large increase. However, timber was listed as one of the top scarce products. Since then, timber prices have risen throughout the 1980s. Since the mid-1990s, timber prices have somewhat decreased because of a growing timber supply from the plantation forests, timber imports and some changes in the economic structure of the country.

Figure 7 indicates that the timber production in regions with poor forests, such as in Northwest and North China, increased earlier than in the well forested areas, such as in Northeast China. The transition may in fact come out as an increase in timber production through a change from a regime of non-actively managed forests to a regime of actively managed forests.

It should particularly be emphasized that scarcity includes environmental goods that generally do not yet have a market price. If we view the economy as being open, timber can be imported from other regions or other countries, so scarcity – if we use price as the measurement – can hardly go beyond a certain level. But most environmental goods are supplied on-site and cannot be imported. Local supply is therefore often necessary. An increasing share of the afforestation in China is environment oriented as it is in other countries and regions. As an example forest management in Singapore and Hong Kong or other highly populated regions is clearly not for timber production, but for the supply of environmental goods.

In China, the timber scarcity since the 1990s has been eased to some extent due to massive plantations of fast-growing trees and imports. However, the demand for environmental goods is also growing fast due to population growth and economic development. In China more than 16 mill. ha of protection forests, accounting for 14% of the total forested area, is aimed at environmental services. The protection forests are mainly located in the three northern areas (North, Northwest, Northeast; see Table 4). Ten of the eleven recently implemented



Note: The price is deflated by the retail price index.

Figure 6: Timber procurement price index in China, 1951–1995 *(China's Statistical Bureau 1989 and 1996)*

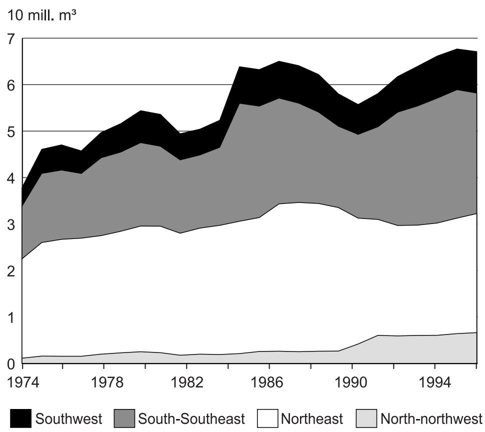


Figure 7: Industrial timber production in China by regions, 1974–1996

Table 4: Main environment oriented forests in China

Region	Total land area (mill. ha)	Percentage of land area of China	Total forested area (mill. ha)	Protection forest area (mill. ha)
Three-North Region	408.4	42.3%	15.3	4.1
Upper and middle-reach of Yangze River	49.3	5.1%	10.2	1.4
Coastal region	25.1	2.6%	5.3	0.9
The plains region	134.5	14.0%	12.7	2.5
Total	657.3	68.9%	43.5	8.9

(Ministry of Forestry 1989; 1995)

massive afforestation programs were initiated specially to combat environmental problems (Zhang et al. 1999). In addition, about 9 mill. ha of forestry land are preserved as natural reserves, for either environmental or ecotourism purposes.

Rudel (1998) has argued that a scarcity of timber might not induce reforestation because of potential substitutes for wood and the time lag of reforestation. Substitutes for wood really ease wood scarcity, may prevent wood price increase and can delay the reforestation. However, looking for wood substitutes is a process actually induced by the scarcity timber. The time lag of regeneration is really considerable, and with sustainable forest management a considerable time between two rotations is required. Forest change is thus sometimes misunderstood, partly because of the short-term activities overshadow the long-term perspectives.

Institutional Transition

Palo (1994) among others has argued that the forest transition is often not realized because of market failures and inappropriate property rights, political unrest and missing information in developing countries. This argument only explains that scarcity is not a sufficient reason, but does not deny it as necessary reason for the forest transition. It must be realized that scarcity is the motivation for ownership and market exchange. China experienced shortages of timber supply in the 19th century (Shaw 1914; Pen 1922; Murphey 1983). Without considering either the transaction costs or risks, China's forest transition – at least at a regional level – should have occurred in the late 19th century: in fact, forest management in China has over 1000 years of history. Unfortunately, between the late 19th and the mid-20th centuries, China suffered from continuous wars. Confronted with such unrest the environment for long-term investment, such as forest mana- gement, was hostile.

Within the People's Republic of China, great efforts have been made concerning afforestation. China was widely recognized as having the world's largest forest plantation area (Westoby 1975; FAO 1978). The continued political struggles did mean that afforestation measures, more specifically institutions governing the measures, proved to be ineffective. Logging on the natural forests still outweighed the efforts in afforestation. The radical deforestation during the Great-Leap-Forward in 1958 and the Cultural Revolution from 1966–1976 was completely a result of institutional problems.

The inappropriate assessment of a 8% of forest cover in 1949 and 12.7% in 1976, as well as rampant false reports on the afforestation achievement, overshadowed the deteriorating status of China's forests. Only when the data from second national forest inventory (1977–1981) showed a decline of the forest resources, was the serious state of China's forests given attention by the general public. A growing demand for wood, resulting from both population growth and economic development, had to rely on huge imports of forest products during the 1980s. The state-owned logging enterprises also faced a serious economic crisis. Deforestation resulted in an increase in environmental damage and the frequency of natural disasters.

These signals and concepts of scarcity called for a revision of the general forest policies. To increase both the forest cover and the growing stock became a top priority. The strategy was changed from "mining" the forests – moving Point D and C to right in Figure 1, to a silviculture-based forestry – moving Point B to the right. Large scale funding and efforts have been allocated to silvicultural investments. Numerous massive programs for industrial timber supply, soil and water conservation, coastal natural disaster prevention, biodiversity preservation, etc. have been implemented (Zhang et al. 1999).

Institution Building in Forestry

Institutions have clearly played an important role in both deforestation and the forest transition. China's land tenure had developed already at a much earlier time to the level of today's capitalistic countries in the beginning of the past century. Almost all agricultural land and a large part of the forest land had been owned by landlords and some rich peasants for centuries. Some institutions and land market mechanisms for such private ownership had also been developed. Those institutions have been the basis for socio-economic development. Unfortunately, the land reform from 1949 to 1952 and the follow-up socialist transformation, completely destroyed these institutions. In the short term, the land reform did have some positive effects on rural development and equal income distribution, but the long-term negative impact is significant and far-reaching. Building institutions is much more difficult than destroying them. North (1991) pointed out that institutional change is a complicated process. Although formal rules may change overnight as the results of political or judicial decisions, informal constrains embodied in customs, traditions, and codes of conduct are much more impervious to deliberate policies.

Recent reforms are trying to rebuild the institutions and management organizations with respect to (1) clarification of forestry land property rights through forestry land owners' re-titlement. While there is still no recognition of private land ownership rights, at least private land-use rights and forest property rights are recognized; (2) the role of law in forest management is being addressed, and significant forces are being provided to protect economic rights in forests, as well as helping to provide solutions where disputes occur. The Forest Law was firstly enacted in 1985 and amended in 1998; (3) a free timber trade is gradually being permitted which recognizes the economic rights to forest products; (4) the de-collectivization and reorganization of collective forestry land is progressing through the Household Responsibility System and the Share-holding System and other types of joint or co-operative management; also (5) de-centralization of the state-owned forestry land is occurring through dissolution of the management authority and budget regime.

Institution building has proved difficult and time consuming, not only in term of the institutions themselves, but also in terms of the credibility of the government. Even after two decades of considerable efforts by various governments promising that forests owned either privately or collectively will be legally protected by laws, the farmers are still in doubt whether the government will always maintain such a policy. This again demonstrates how difficult it is to rebuild institutions once they have been destroyed. However, these reforms have already helped the forest transition to some degree (Ruiz-Peres et al. 1996; Yin and Newman 1997; Song et al. 1998), and will play a more important role in the future.

5 Prospects for the Future

Forecasts of China's forest and land use trends have been made by the Chinese Society of Forestry (1987) and Gu (1988) among others. Errors in the forecasts are becoming obvious. The problems lie in the fact that they are based either on past trends, government planning or political opinions. Even though some of the models are very sophisticated and seem to consider comprehensive variables, the most important mechanisms driving the forest transition and the response to scarcity are still not taken into account. Alternatively, let us examine a very simple way to predict the future of forest land change.

Forestable versus Unforestable Land

Before the conversion between different land uses is analyzed, technically *unforestable* land must be excluded. Unforestable land refers to the biological limits of tree growth because of factors such as temperature, soil, altitude and water. Currently, about one third of the land in China, mostly located in the northwest and southwest China, is to some extent technically unforestable. Of course, "unforestable" is a relative concept in the long-term. Some of the most favorable "unforestable" terrain has been and will be forested, while some *forested land* and *potentially forestable* land has degraded into unforestable due to the loss of reversibility resulting from heavy and repeated damage, for instance over-harvesting and over-grazing. Significant shifts in land use do not seem likely, in spite of the great efforts such as silvicultural technology developments, which have been made to overcome some of the biological limits in the northwest region. Meanwhile, some marginal land continues to degrade to become unforestable. A minor net positive change depends on the economic status, technological development, policy and public awareness of the environment in the future.

Forestry versus Competing Land Uses

The boundary of forestry land and non-forestry land is Point A in Figure 1. The causes of the boundary change has been discussed above. Economically, agricultural use is becoming less competitive: agricultural products in general are more expensive than imports. China's entrance to the World Trade Organization will further lower the general price level of agricultural goods. The long history of agriculture has left little potentially arable land in existing forested land, so the possible shift from forested land to agricultural land could be comparatively minor.

On the general issue of food security, China will invest in its agricultural infrastructure, which is intended to increase productivity and improve some of the degraded agricultural land. In the short term, imports of agricultural products are expected to increase. The policy for food self-sufficiency, at least at the regional level, is gradually losing support due to its inefficiency. Therefore, increased government subsides for agriculture can be neither justified nor expected. Since the social price of the outputs from forest management is much higher than the timber market price, it is likely that subsides to forestry, government direct investments and loans, will be increased. Agroforestry and urban forest development are other alternatives for overcoming land limitations and combining forestry and agriculture.

Point A in the Figure 1 is not very appropriate because it only indicates the shift between forestry and agriculture. Theoretically, a growing population and industrialization will occupy more agricultural land, putting more pressure on agricultural land and pushing agricultural frontier A to the right, utilizing directly forestry land. However, current population movements and industrialization are characterized by road improvements, expansion and urbanization. In other words, new large settlement sites, even the establishment of small villages, as in the 1950s and 1960s, is less possible and not encouraged by the government. Forest management may therefore benefit more than agriculture in reduced costs resulting from road expansion and improvements.

To sum up, the total net conversion from forestry land to the competing land uses, including agricultural, residential and industrial land, may no longer be significant (see Table 3 and Figure 5). As a nation, China has "matured". As far as land use is concerned, there will never again be radical and rapid changes in major land uses such as occurred during history. The change within each category is likely to be greater than the change between the categories. Changes in major uses of land will tend to be localized since no large population migration is possible except from rural areas to urban areas. The conversions, at least the net change from forestry land to other categories, are gradually becoming insignificant and in the future may possibly be from other land uses to forestry.

Forests in the Future?

The changes within forestry land refers to the area located to the right of A in Figure 1. Future forest changes will mostly be within this category. Firstly, consider Point D or C in Figure 1. Given the current population density and distribution, Point D has almost approached E. That means China has few frontier forests and little virgin land. The remaining virgin forests, together with some secondary natural forests, have been protected to fulfill environmental functions. The extensive floods of the late 1990s across China led to a re-appraisal of the natural forests, resulting in the full implementation of the bans on logging in natural forests. Marginal timber extraction from natural forests might be unavoidable but only selective cutting is allowed. In this sense, these forests are neither frontier forests nor non-actively managed forests, but managed forests and their value is reflected in their environmental functions. Therefore, neither a small rise in timber price nor a decrease in extraction cost should be a threat to them. In fact, the increase in environmental value caused by the growing demand and decreasing supply of environmental services will help their protection, management and expansion. Increasing large-scale protection forests and nature reserves are good examples of this process.

Secondly, consider Point B in Figure 1. Forest land under active management – mostly plantation forests – are likely to expand, assuming that timber prices will continue to rise. This assumption may be valid since less timber will come from natural forests, and more subsidies or tax cuts can be expected. More importantly, improving the socio-economic conditions and institutions, including laws and property rights security, will reduce the protection costs and the risks that investors must bear. The development of institutions has already played a role in the forest transition and will continue to be important in the sustainable expansion of forests.

Finally, consider the area from B to C in Figure 1, that is to say, forestry land under the non-active management. This area may be the most important section for future change, as about half of forestry land, or 15% of the total territory of China, is in this category (see the categories of bareland, open forest and shrubs in Figure 5). As already discussed, it is the transaction costs rather than the traditional production costs which make active forest management uneconomic. The role of institutions, which is important in reducing transaction costs, will be even more important for its transition into active management.

To forecast the future changes in the forests of China, attention should again be given to the land between B and C in Figure 1, denoting bareland, open forest and shrubs. The area of this land category accounts for 15% of the total land area of China. Focusing on this land and considering the future development of the economy, institutions and markets, some simple predictions can be made as follows:

- In the short term (5 years, up to 2005), on the assumption that the current distorted timber price with heavy tax and fees continues, institutions regarding land tenure and macroeconomic policy will improve steadily but will not change significantly. It is expected that 17% of the land area of China, equal to the current forest cover of 15% plus 2% through afforesting 5–15% of the land between B and C, is likely to be covered by forest in 2005.
- In the medium term (20 years, up to 2020), on the assumption that institutions will experience some significant progress, the distorted timber supply price will be adjusted and more non-market values of the forest will be considered. It is appropriate to use the international prices of agricultural goods and wood products as shadow prices. Under this assumption, around 22% of the land, which is equal to the current forest cover 15% plus 7% through afforesting 50% of the area between B and C, could be covered by forest.
- In the long term (50 years, up to 2050), it can be assumed that institutions will reach the same level as in the current developed world, and the non-market value of water and soil conservation, carbon sequestration, biodiversity preservation and other environmental functions will be considered in government decision-making. It can therefore be expected that about 28% of the land, over 200 mill. ha, which is equal to the current 15% plus 13% through afforesting 90% of the area between B and C, will probably be under active management.

6 Concluding Policy Implications

Deforestation is unavoidable in any country with rich virgin forests. The growing demand for agricultural land and timber by either a local population, or population growth through resettlement, are important reasons for deforestation. However, for a country like the current China, where few frontier forests are left, timber will become more scarce and worth managing. Therefore, a forest transition will be likely to occur. However, there is insufficient justification for active forest management to be derived from traditional production economics. The transaction costs of land property rights consist of the costs of *ex ante* and *ex post* of transactions. All potential land rent will dissipate whenever the land is in open access. However, the potential gains from open access to closed access will also dissipate if the transaction is too costly. The transaction costs are important factors for the transition from non-active to active forest management. Therefore, institutions are critical, since transaction costs greatly depends on them.

Based on the previous discussion, some policy implications regarding China's future forest development can be outlined:

- The first priority is to emphasize the development of institutions to significantly reduce property right protection costs for forest management and to provide more security and confidence for farmers concerning the continuity of the property rights. This will accelerate the transition into active management in the area between Points B and C in Figure 1, which today accounts for 50% of total forestry land.

- The second priority is to reduce taxes on timber production and adjust the taxation in order to increase the current forest management intensity by using price incentives. This would effect the area between A and B and would encourage the shift of Point B to the right. Lump sum tax could be a good alternative.

- The third priority is to allocate government funds to protect those highly fragile and environmentally significant forests, located to the right of Point C in Figure 1.

Currently, it seems that government efforts are still focusing on direct investment through launching massive forestation programs. This may not be the most effective approach. Without the institutions that create cheap exclusion costs, closed access is unfeasible. Without closed access, any investment in silviculture is wasted money. If forest management is profitable, private investment will be induced. The priority of government should be to invest in institution building that would promote the definition, transference and protection of property rights.

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