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Foreword by Wen-Yue Hsiung

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Foreword

Historically, dense sub-tropical, evergreen, broadleaf forest and mixed forest of conifer and broadleaf trees covered the middle and lower reaches of the Yangtze River basin. This area has the largest lakes in China, which, because they can store flood water, form a harmonious system with the Yangtze River. But when humans began to have impacts on the hills through time, the forests were seriously damaged. The natural forest was replaced by plantation forest for wood utilization, which was usually of low forest quality and low biodiversity, as well as suffering from serious water and soil losses, and causing frequent flooding. This situation seriously affected the sustainable development of society, both economically and in terms of regional ecological safety. In addition to regional physical and hydrological conditions that cause flood hazards, the combination of land reclamation and population growth created an environmental bomb, which resulted in the worst flooding in China since 1954 in the 1998 Yangtze River flood. The flood claimed more than 2000 lives and engendered economic losses of US $25,000 million. The 1998 Yangtze deluge was measured to be a 150-year flood, but the water flux was only a 60-year event. Scientists were inclined to attribute this extreme event to El Niño, a periodic warming of the eastern Pacific that began in 1997 and extended through the first half of 1998. Nevertheless, both observational and theoretical studies have proven that the destruction of natural vegetation cover, such as destructive lumbering of forests and over-cultivation and overgrazing of grassland, has been one of the major causes for the deterioration of the regional climate and environment.

Before 1980 in China, forest reforestation implied cultivating plantation forest for wood and for economics with few tree types. After the 1980s, the Chinese forestry system consisted of a developed forestry industry, and maintaining a healthy ecological system was determined as the main aim and guiding idea for a sustainable forestry development strategy. China is an agricultural country with 700 million farmers, most of whom were poor and used wood for construction, and used grass, shrubs, twigs, and litter of trees and straw as fuel for cooking. There was a strong desire to get rid of poverty from these mountainous areas and other areas of limited arable land. Based on local conditions, it was urgent for peasants, technical workers, and officials to reforest bare land, hilly, or highly sloping land that had formerly been cultivated, and land suffering desertification due to serious water and soil loss in southern China. It should be pointed out that the subsidies from the government for reforestation of steep hilly land that was formerly cultivated land are just enough for 3–5 years' income of the same cultivated land, and reforestation on bare land only provides money to farmers for weeding and management. Reforestation and economic interaction work should improve not only the ecological environment but also the living standards of local residents, which in turn will increase the awareness of the concept of environment protection of the local residents. Finally interaction among reforestation, community, and the economy can get rid of vicious cycle of the poverty trap.

This book *Theory and Practice of Soil Loss Control in Eastern China* by my good friend and coworker Prof. Zhang Jinchi, Prof. Donald DeAngelis, and Dr Zhuang Jiayao concerns not only the development of models for soil loss prediction but also reforestation techniques for water and soil loss control in the hilly and mountainous areas in the lower reaches of the Yangtze River, which have been carried out creatively and with great effect as a multi-functioning system by forestry scientific workers. With the development of society and economics of the Yangtze River delta, demands from residents for a good ecological environment have greatly increased. Thus, synergistic interaction between mountainous and hilly regions in the high-elevation catchments, such as the Dabie Mountains and the Daba Mountains, which can produce a good environment, keep water clean and protect the lower reaches from flooding – but lack money – and urban areas in the lower reaches, such as Nanjing, Wuxi, and Shanghai, which need clean water from the mountains urgently, but do know how to get it effectively, can be reached. This book also proposes that interactions between urban areas in the lower reaches, which provide money and technology, and the countryside, where ecological restoration for water and soil loss control with the use of reforestation, biogas, and solar and water energy, should be formed in the lower reaches of the Yangtze River in eastern China. This will decrease the differences in wealth between the countryside and the city and achieve an economic integration of city–countryside. In this sense, this book is good not only for technical workers in soil erosion control and forestry but also for strategies of managers in all the undeveloped countries of the world.

Nanjing, China Wen-Yue Hsiung

Preface

Not only is much of the region of the middle and lower reaches of the Yangtze River characterized by steep hills but also it contains the densest population and most economically developed area in China. Due to intense impact of human activities, forest resources have suffered serious damage, resulting in a low quality of forest, made up of a few types of plantation forest with simple structure and low capacity for water and soil loss control. In addition, due to the steep gradients of the hills, high susceptibility indices of soil erodibility, and plentiful rainfall of non-uniform distribution, intense water and soil loss, as well as landslides, occurs frequently. These geomorphologic and natural environmental characteristics determine that for the currently bare lands, steep hillslopes currently under cultivation, and the lands that have undergone desertification, reforestation is the only choice for achieving regional sustainable development and the realization of a harmonious relationship between man and nature.

Up until recently, research on forestry ecological engineering for water and soil loss control has made great progress on small areas or on single forest communities, but there is still a lack of synthetic research and model demonstration at the catchment scale. Because of the long timescales in forest development, the theory and methods of reforestation were mostly reached by means of substituting space for time in basic research, so it was technically difficult to make comparisons across space. More recently, researchers have performed blocks of experiments and demonstrations of reforestation in the provinces of Jiangxi, Anhui, Jiangsu, Zhejiang, etc., and acquired much support from Chinese national research projects over a period of 20 years and achieved much success. Based on the past research results and monitoring data over this long period, this book first presents the several proposed soil loss prediction models.

For soil loss control in the mountains of China, the first step is the determination of appropriate strategies. There is an urgent need for soil loss models that can provide sufficient information for making strategies to control soil loss using field observation data taken over short periods, such as several years. The USLE (universal soil loss equation) models were developed in the USA in the 1960s and applied for average annual soil loss prediction widely in the world. But their application requires observational data over many years. In addition, the USLE models do not take much account of the typical operations of human beings that are usual in China's cultivated lands. With the development of economy, controlling the environmental problems has become so important that more information should be provided for making soil loss control strategies based on field observation data over just a few years. Furthermore, soil loss control needs the cooperation of farmers and local residents. Effective soil loss models facilitate the communication between environmental experts and farmers and citizens.

This research also proposed a systematic application of the GOIUG (GIS-based observed instantaneous unit graph) model, integrated to make graphical predictions of instantaneous suspended sediment discharge with GIS, the IUG method, and a hydrologic model, which is used to simulate the suspended sediment generation and its transmission to the outlet. It helps to elucidate, quantitatively, the source of sediment discharge. Furthermore, a model of ER (effective rainfall erosivity)-USLE was developed from USLE to predict annual soil loss based on single events with an effective rain erosivity factor. The model portrays the interactions among seasonal precipitation, seasonal crop coverage, and individual operations by human beings (P_s). The litter factor is incorporated into USLE in order to create a FUSLE model for application in forests. These models are believed applicable with higher accuracy in China and suitable for strategy making in soil loss control in the cultivated land and forest management.

Second, this work developed many types of reforestation, especially some key techniques, such as secondary forest culture with a focused tree plantation method, agriculture–forestry methods in the hills, reforestation in extremely eroded areas of red soil, and forest soil fertility protection. These methods are providing technical support for nationally important projects, such as the Chinese natural forest protection, reforestation in cultivated land at slopes above 25°, and wood forestation forest construction in southern China.

In particular, techniques of reforestation also focused on improving the living standards of farmers, proposing a "small recycling" system made up of tree, crop–feeding–biogas–fertility–fishing, etc and a "big recycling" system made up of interaction between the countryside of mountainous areas and the urban areas in the lower elevations. The "small recycling" can not only make money for the farmers effectively, while keeping the environment clean from being polluted by animal excrement, but also save fuel materials such as twigs and litter of tree, and shrub and grass from being collected, thus protecting the reforested young trees from harm. The "big recycling" makes a harmonious society, with the aim of common health and wealth.

We have a long cooperation in eco-restoration with world famous ecologist, Professor Donald DeAngelis. During his recent visit in China, he was very pleased with the rapidly increasing forest coverage in south China. He thought the fast reforestation method may not only be useful in China but also provide a good model to eliminate poverty for the poor farmers in the other undeveloped countries all over the world. In addition, effective reforestation will enhance the effort to slow world climate warming. Then we discussed the possibility of compiling a book on reforestation techniques and soil loss control theory for the purpose of providing useful assistance to researchers, university graduates, and foresters. Both of us believed that is was the right time to compile a book integrating our common research progress and assessment on reforestation and soil loss control in eastern China.

Nanjing, China J.C. Zhang

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Contents

Part I
General Characteristics of the Hilly Region of Middle and Lower Yangtze River

Chapter 1
Ecological and Environmental Characteristics in the Hilly Region of Middle and Lower Yangtze River

Abstract The Yangtze River is one of the most important rivers in the world. Its middle and lower reaches lie in the subtropical monsoon area of east Asia, which has a warm and moist climate with clear distinction between the four seasons. The vegetation in the middle and lower reaches of Yangtze River takes on conspicuous vertical zoning characteristics. From low to high elevation, the vegetation makes a transition from evergreen broadleaf forest to mixed evergreen broadleaf and deciduous forest. The species diversity of forest plantations in the middle and lower reaches of the Yangtze River has very important status in China. The present problems of soil erosion are based mainly on the following factors: (1) plentiful precipitation provides strong force for water erosion; (2) the inhomogeneities in the temporal and spatial distributions of precipitation result in both frequent flood and drought calamities; (3) simple forest structure and monocultures of trees cause fragility of the forest ecosystem; (4) the sharp increase of population has made the forest destruction more serious and has caused flooding. Because water and soil loss has constrained the development of eastern China, the control of soil loss has been deemed as of primary importance in reforestation.

1.1 Introduction

Land use plays an important role in the phenomena associated with global change (Zhang et al., 1999). It is directly related to food security, urbanization, biodiversity, trans-boundary migration, environmental refugees, water and soil quality, runoff and sedimentation rates (Turner, 1989). Over thousands of years, land use and land use change have been transforming the ecosystems of Yangtze valley, which is now the home of 400 million people.

The Yangtze River is one of the most important rivers in the world. It is the third longest and ninth largest in basin area (Fig. 1.1). Its water discharge is the largest in the western Pacific Ocean and the fifth largest in the world, and its sediment load is the fourth largest in the world (Zhang and Hu, 1996).

The Yangtze River originates in the Qinghai-Tibet Plateau and extends about 6300 km eastward to the northern East China Sea at around 31°30′N and 121°30′E. The headwaters of the trunk stream are located 5100 m above the sea level, which implies a mean longitudinal profile gradient of 0.08%. It flows through 11 provinces: Qinghai, Tibet, Sichuan, Yunnan, Chongqing, Hubei, Hunan, Jiangxi, Anhui, Jiangsu, and Shanghai, in that order. The drainage basin is located between

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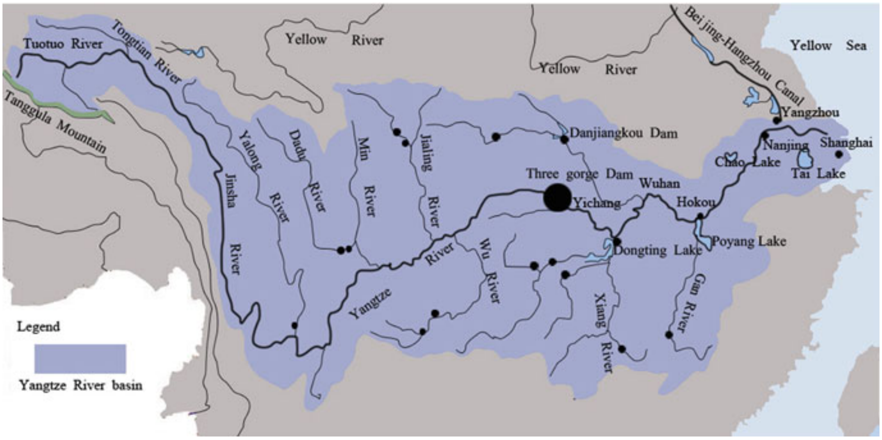

Fig. 1.1 The Yangtze watershed and its tributaries

24.5 and 35.5°N and the climate is characteristic of the subtropical and warm–wet zones. The mean precipitation is 1000–1400 mm/year and the evaporative power (maximum potential evaporation) is 700–800 mm/year in the drainage area. Precipitation and runoff vary with season, with 70–80% being distributed in the rainy season from May to October. Its catchment basin covers an area of 1,808,500 km^2 (18.8% of the territory of China) and has a population of more than 400 million (one-third of the Chinese population). This chapter concerns the ecological and environmental characteristics of the hilly region of the middle and lower reaches of the Yangtze River.

The middle and lower reaches of the Yangtze River consist of the southern region of Huaihe River, the Daba Mountains, the eastern region of the Wuling Mountains, and the northern region of the Nanling Mountains (Fig. 1.2). Regarding the administrative range, it includes most parts of Hubei, Hunan and Jiangxi provinces, etc., and parts of Anhui, Zhejiang, and Jiangsu provinces, as well as Shanghai (Fig. 1.3). The total land area of this region is 91.03 km × 10^4 km, accounting for 9.5% of China's whole territory. Because of the dense population, large agricultural population (31.3% of the total agricultural population in China), and relatively small arable area (only 18.8% of China's total arable area), most of the low mountains and hills with relatively better water and soil resources have been reclaimed to dry cropland, resulting in a high cultivation index. Granite, gneiss, purple shale, and limestone are common parent rocks in this region. Soil conditions vary considerably here. On the one hand, on the vast hilly region to the south of the Yangtze River is distributed mainly red and yellow soil, which is clayey, acidic, and thin. Soil organic matter does not readily accumulate, and thus the soil is low in yield. On the other hand, the region north of the Yangtze River has mainly yellow brown and yellow cinnamon soil with poor structure, high clayey texture, and weak ability for water storage and drought resistance.

Fig. 1.2 The main rivers and mountains in China

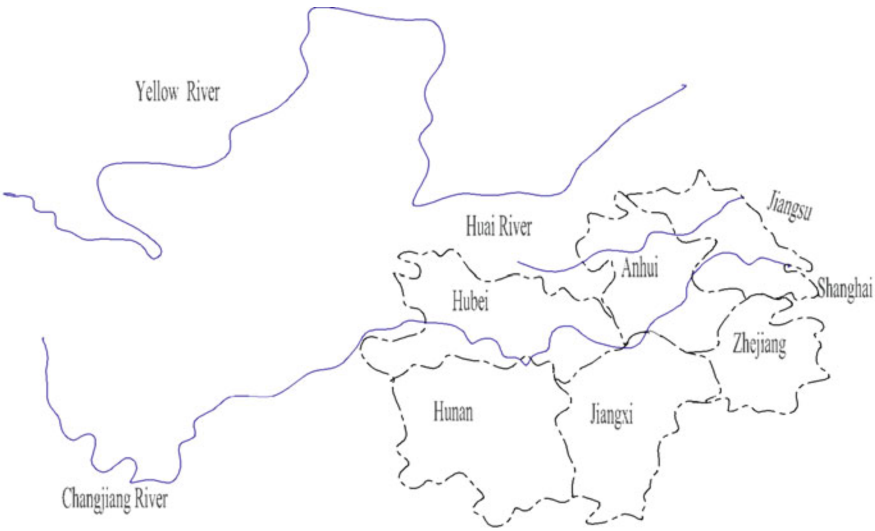

Fig. 1.3 The administrative divisions in east China

1.2 Physiographic Conditions

Being a subtropical monsoon area of east Asia, this region has a warm and moist climate with clear distinction between the four seasons; it is hot in summer and cold in winter, with a long free-frost period. Both precipitation and temperature

Table 1.1 Areas of mountains, hills, and plains in each province in the middle and lower reaches of Yangtze River

	The proportion each geomorphic type takes up in total land area (%)		
Provinces	Mountain	Hill	Plain
Anhui Province	31.2	37.5	39.3
Jiangxi Province	30.4	44.4	25.2
Jiangsu Province	–	15.0	85.0
Hunan Province	51.2	29.3	19.5
Zhejiang Province	21.3	49.1	29.6
Hubei Province	55.5	24.5	20.0

are rather high here with an annual average precipitation of 1100 mm and up to 1800–2000 mm in some areas. It has two rainy seasons: one is the plum rain season between spring and summer and the other is the typhoon rain season in summer. This area ranks as one of the regions that have the longest rainy seasons in China, which is very beneficial for the growth of crops and forests. As a result, the growing season in this region is long.

The terrain of China is higher in the west and lower in the east, which is like a three-step ladder. The middle and lower reaches of the Yangtze River consist mainly of plains, hills, and mountains, with low mountains and hills accounting for three-fourths of the whole area. The areas beside its trunk channel and tributaries have low elevations, making the third terrain of the three large terrains in China. The area around Yidu City along the Yangtze River consists mainly of plains, with the watershed as its periphery, low mountains and hills of Huaiyang in the north, and low mountains and hills of Jiangnan in the south (Zhou, 2005).

Hills and mountains cover more than 65% of the total territory of most provinces, except in Jiangsu Province and Shanghai (Table 1.1). Larger cordilleras run mostly from northeast to southwest. These include the Wuling cordillera in the west of Hunan Province, the Xufeng cordillera, the Luoxiao cordillera on the border of Hunan and Jiangxi provinces, the Mufu cordillera on the border of Jiangxi, Hubei, and Hunan provinces, the Wuyi cordillera on the border of Fujian and Jiangxi provinces, the Huayu cordillera near Zhejiang and Jiangxi, and others. The cordilleras that run from northwest to southeast are the Daba cordillera between Hubei Province and Chongqing City, and the Dabie Mountain cordillera between Hubei and Anhui provinces. The Nanling Mountains run across Hunan, Jiangxi, and Guangdong provinces from east to west. Between these cordilleras and plains there are widely distributed hills, including the Jiangnan hills in the middle and southern part of Hunan and Jiangxi provinces, the western part of Zhejiang Province, and the southern part of Anhui Province, covering an area of 37 km $\times$ 10^4 km.

The plains in the middle and lower reaches of Yangtze River include the Jianghan plain, Dongting Lake plain, Poyang Lake plain, the plain in eastern Hubei Province along the Yangtze River, the plain and delta in Jiangsu and Anhui provinces along the Yangtze River, and some lakes and coastal plain. The Jianghan plain is made up of Yidu, Jingzhou, Shishou, Jiayu, Wuhan, Tianmen, Zhongxiang City, etc, with an elevation range of 20–40 m. Because the ground level of the river bank is 3–15 m lower than the historical floodwater level, flood calamities occur frequently and the flood control situation is very serious. The Dongting Lake plain consists of the U-shaped delta and alluvial plain, which is enclosed by Dongting Lake, Jinshi, Yiyang, Miluo, and Yueyang, and is open to the north. The elevation of this plain is 22–32 m, 20 m lower than the historical flood level, with the 2,625-km^2 Dongting Lake playing an important role in adjusting and delaying floods. The plain along the Yangtze River in eastern Hubei Province is made up of high valleys with flat and first grade terrace topography. With a general elevation of 12–25 m, it has intermittent dikes constructed along the Yangtze River. The Poyang Lake plain includes the Poyang Lake and its surrounding alluvial plain. The elevation along the lake is 14–17 m, generally 6–10 m lower than flood level. With an area of 3913 km^2, it can regulate and store water during the flooding season and provide supplementary water for the lower reaches of Yangtze River during the low water season – it is a typical lake, which both receives intake water and discharges water. The plain in Jiangsu and Anhui provinces along the Yangtze River includes the alluvial plain along the Yangtze River between the cities of Jiujiang and Nanjing and its tributaries. Its elevation is 8–20 m, 1–8 m lower than the flood level. There are many lakes on both banks of the Yangtze River, among which the largest is Chaohu Lake on the northern bank, with an area of 780 km^2. The delta and littoral plain consists of northern and southern Jiangsu Province, northern Zhejiang Province, and Shanghai below Zhenjiang City. Generally speaking, its elevation is 2–5 m, 0.5–3 m lower than flood level. There are relatively more lakes on the southern bank, with Tai Lake being the largest, with an area of 2460 km^2 (Zhou, 2005).

The area in the middle and lower reaches of the Yangtze River crosses five tectonic units – the Qinling fold system, the Yangzi Para platform, the south China fold system, the Sino-Korean Para platform, and the southeast coastal fold system – and belongs to the Paleozoic structural belt and plateau cover fold belt in the phase of Yanshan.

With the advantage of such environmental characteristics as the geomorphology of low mountains and hills, of soil, of climate resources, and so forth, the region in middle and lower reaches of the Yangtze River is not only an area of concentration of subtropical evergreen broadleaf forests but also a base for the cultivation of timber and pulp forests, as part of the system of plantation forests in China. Warm and moist natural conditions nurture rich and varied natural vegetation and a complicated forest ecosystem in this region. The virgin forest in the south of this region is evergreen broadleaf forest, while vegetation in the north displays transition characteristics from the subtropical zone to the temperate zone. Vegetation biodiversity has a highly important status in China.

1.3 The Vegetation Characteristics

1.3.1 Distribution of Vegetation in the Middle and Lower Reaches of the Yangtze River

The virgin vegetation in the south of this region is evergreen broadleaf forest, the major components of which include *Castanopsis*, *Lithocarpus*, and *Cyclobalanopsis* in the beech family; *Cinnamomum*, *Phoebe*, and *Machilus* in the laurel family; *Schima* and *Camellia* in the tea family; and *Manglietia* and *Michelia* in the Magnolia family. In addition, *Ilex a*nd *Symplocos* are also commonly found there. In Anhui Province, there are 3320 kinds of angiosperms, 13.3% of the total 25,000 kinds in China; 72 kinds of gymnosperms, 36% of the total 200 kinds in China; 253 kinds of ferns, 9.7% of the total 2600 kinds in China; 600 kinds of bryophytes, 27.3% of the total 2200 kinds in China. There are 6455 kinds of major plants cultivated in Anhui Province, such as the mung bean in Mingguang, hickory nut of Ningguo, chrysanthemums in Huizhou, and papaya in Xuanzhou. All of them are unique varieties, famous both at home and abroad. In recent years, the area of artificial forest in the middle and lower reaches of Yangtze River has been expanding steadily. Influenced by the plantation forests, vegetation has been restored quickly. Taking Taihe County of Jiangxi Province as an example, before the year 1991 when the plantation forests planting program was started, there were only seven plant species, most of which were light-loving and drought-resistant graminaceous plants, such as green bristlegrass herb (*Setaria viridis*), Arundinella hirta (*Arundinella hirta*), Cherokee rose (*Rosa laevigata*) and Smilax china (*Smilax china*). After plantation forestation, the number of species increased to 21 in 1993 and 58 in 2001. Some foreign plants, which originated in tropical America and North America, such as licorice (*Glycyrrhiza uralensis*) and annual fleabane herb (*Erigeron annuus*), are beginning to enter the plantation forests.

The vegetation in the middle and lower reaches of Yangtze River takes on conspicuous vertical zoning characteristics. From low elevation to high location, the vegetation makes a transition from evergreen broadleaf forest to mixed evergreen broadleaf and deciduous forest (Ke et al., 2002) (Fig. 1.4). The conifer forests in this region are distributed as an "inlay" type, that is, interweaving into other forest types or mixing with the broadleaf trees. Conifer forests here are mostly thermophilic ones, among which Chinese fir (*Cunninghamia lanceolata*) and Masson pine *(Pinus massoniana*) are the main species grown here. In addition, the Mao bamboo (*Phyllostachys edulis*) forest occupies a certain area in this region in a natural mosaic pattern. The vegetation in the north has the characteristics of transition from subtropical zone to temperate zone. On the one hand, the broadleaf forest includes deciduous forests, which are the most common, and evergreen ones, which are mainly distributed south of the Yangtze River. Of the deciduous forest types, Liaotungensis genera (*Quercus* L.), Chinese beech (*Fagus* L.), poplar (*Populus* L.), etc. are the most popular for plantation forests. Because of the differences in micrometeorology between hills and valleys, the evergreen broadleaf forest consists of different varieties and proportions. The major evergreen

Fig. 1.4 Distribution of vegetation types in the Yangtze River watershed. *I*, Broadleaf evergreen vegetation; *II*, broadleaf deciduous vegetation; *III*, needle-leaved evergreen vegetation; *IV*, dwarf shrubby; *V*, high-cold steppes and meadows; *VI*, alpine sparse vegetation; *VII*, cultivated vegetation; *VIII*, no data area

broadleaf trees are Cyclobalanopsis oak (*Cyclobalanopsis glauca*), bitter mesophanerophytes (*Castanopsis sclerophylla*), rock oak (*Lithocarpus glaber*), Purple phoebe (*Machilus sheareri*), and red phoebe (*Machilus thunbergii*), etc. The coniferous trees include both warmth-loving ones such as masson pine, Chinese fir, Bashan Torreya (*Torreya fargesii*), and cedarwood (*Cupressus funebri*), and cold-resistant ones, such as spruce (*Picea brachytyla*).

1.3.2 The Characteristics of Biodiversity in the Middle and Lower Reaches of the Yangtze River

The species diversity of forest vegetation in the middle and lower reaches of the Yangtze River has very important status in China. Statistics shows that in China there are 337 families of seed plants, 3200 genera, and 26,276–27,268 species (Li, 1996). There are 52 families of fern, 204 genera, and 2,600 species (according to the statistics of the editorial committee of "Chinese Physical Geography" of Chinese Academy of Sciences). There are 2457 species of bryophytes (Redfearn et al., 1996). The number of species of seed plants in China is the third in the world, which is next to Malaysia (about 45,000 species) and Brazil (about 40,000 species). The flora of Hubei and Hunan provinces, in the middle and lower Yangtze River, is the characteristic of the central China district, and that in Zhejiang and Anhui provinces is the characteristic of the east China district. According to statistics (Qi, 1993; Liu, 1995), there are 207 families of seed plants, 1279 genera, and 6370 species in central China, and there are 174 families of seed plant, 1180 genera, and 4259 species in east China. At the family level, central China accounts for almost two-thirds of the flora of China as a whole, and east China accounts for more than one-half of

Table 1.2 Bryophyte diversity in Hunan, Jiangxi, Hubei, and Anhui provinces

Province	Liverwort (family/genus/species)	Moss (family/genus/species)	Total (family/genus/species)	Documents
Hunan	24/34/70	39/110/197	63/144/269	Rao et al. (1997)
Jiangxi	26/43/89	40/109/216	66/152/305	Fang et al. (1998)
Hubei	–	/ /272	–	Redfearn et al. (1996)
Anhui	–	/ /457	–	Redfearn et al. (1996)

the flora of China as a whole. At the genus level, the flora of the four provinces accounts for 40% in central China and 37% in east China. Obviously, the diversity of biological pedigree is quite high. Table 1.2 shows that the biodiversity in the four provinces is considerable. According to the above analysis, the estimated total amount of vegetation, including seed plants, ferns, and bryophytes, is 10,000 species. High biodiversity is the foundation for complex structure and diverse functions within forests, as well as a resource bank of valuable species for the forestry industry.

1.3.3 Current Situation and Existing Problems of Biodiversity

Despite the fact that the species diversity of forest plants in the four provinces is adequate and there are abundant types of plants, the actual situation is not encouraging. For various reasons, many of the existing biodiversity conservation areas are constrained. A large number of species are confined to the limited natural conservation areas, extinction of some species is unavoidable, and the management measure of biodiversity has lagged behind. Present problems are focused mainly on the following aspects:

(1) There is abundant plantation forest, but wild forest area is sparse, with simplified and fragile ecosystems.

In the past 10 years, the forest coverage rate has increased by a large amount (Ke et al., 2003) (Fig. 1.5), through the forestation projects called “Afforestation of the Barren Land Mountains” and “Shelter Forest Engineering Construction Along the Yangtze River.” For example, the forest coverage of Jiangxi Province rose from 40.3% in 1991 to 50.8% in 1994, and the forest coverage of Hunan Province in 1997 was up to 51.41%, and it rose to 25.97% in 1994 in Hubei Province.

The first stage of the project of “Shelter Forest Engineering Construction Along the Yangtze River” involves 27 counties in Jiangxi Province. By 1997, about 1,216,000 ha bare lands were afforested, of which about 119,000 ha were in Xingguo County. However, from the point of view of ecosystem diversity, the species of trees and the structure of forest are not reasonable in this region. The area of the natural forest is limited, and the majority of new cultivated forest is plantation forest. With respect to forest structure, the proportion of material forest is high,

Fig. 1.5 Variation of vegetation in the Yangtze watershed from the year 1980 to 2000. *I*, Decreased significantly; *II*, decreased, though not significantly; *III*, increased, though not significantly; *IV*, increased significantly; *V*, no data area

which accounts for 60–70%, while the proportion of shelter forest is low, accounting for 5–9%. With respect to tree species composition, the proportion of the conifer trees is high, accounting for 74–79%, while the proportion of the broadleaf forest is low, accounting for 21–26%. Undoubtedly, large areas of homogeneous forest with simplified tree species will result in simplified ecosystems. In the past 10 years, due to the campaign for natural environment conservation, which is advocated actively by Chinese government, natural reserves and forest parks have increased remarkably, but this area is still small. There are 24 natural reserves in Hubei Province, the area of which is 220,000 ha, accounting for 1.78% of the territory area. Extant natural forest, especially evergreen broadleaf forest, is surrounded and fragmented by plantation ecosystems suffering from severe anthropogenic disturbances. Therefore, its structure is fragile, with limited integral ecological function. The vulnerability of the forest ecosystem is clear.

(2) The area of broadleaf forest has decreased, and some species have nearly disappeared. According to the forest resource investigation of Jiangxi Province, the area of broadleaf forest decreased from 1,679,000 ha in 1955 to 1,149,000 ha in 1994, of which the arboreal broadleaf forest was mostly secondary forest or plantation forest afforested after the felling of natural forest. A lot of species have disappeared, because the suitable habitat was lost as the broadleaf forest was destroyed, leading to the partial disappearance and extinction of species that had low adaptability. Fortunately, the trend of forest disappearance is being controlled effectively because the area of forest is now increasing.

(3) The distributions of species and plant genetic diversity are decreasing. Because of forest destruction and the fragmentation of the ecosystem structure, many species that previously had a continuous range have became disconnected. Because of

the destruction of habitat diversity, many species have become confined to single habitats, whereas they could in principle be distributed over many habitats. On special sites, anthropogenic disturbances, such as excavating Chinese herbal medicine and selective felling of trees, have caused species originally at high population densities to become thinner and species originally at low population density to become rarer. Red Phoebe, Min Phoebe (*Phoebe bournei*) and Camphorwood (*Cinnamomum camphora)* are typical representatives of evergreen broadleaf forest in the middle subtropical zone, which were distributed along low-altitude valleys and rivers and formed stable communities with other plant types. In the low-altitude areas, the anthropogenic activities are so intense that such typical communities have already become rare. Schima superb (*Schima superba*) and sweet mesophanerophytes (*Castanopsis eyrei*) have high-density populations in the evergreen broadleaf forest but have become rare in many areas.

(4) The fragmentation of forest into patchy landscapes has caused geographic isolation of communities. Because of extensive cultivation and development, many evergreen communities of broadleaf forest have already disappeared in the low hill area. Big orchards, non-irrigated farmlands, and economic forests have taken their place. Some patches of secondary evergreen broadleaf forest are distributed in the boundary areas of catchments of larger mountain systems, with little dispersal between them. Regarding the horizontal pattern, the communities have already effectively become islands, which cannot be organically connected, and finally have become geographically isolated. The biodiversity is menaced at the levels of genetic, community, ecosystem, and landscape diversity.

The disconnected habitat, destroyed habitat, and unreasonable artificial harvesting have decreased the genetic diversity or even led to extinctions. Those consequences have been caused by non-natural activity, which can be unfavorable to human beings and which violates the rule that society should develop in harmony with nature. Genetic diversity of plant communities is still not well understood, but the present research indicates that the level of genetic diversity is low.

(5) There are potentially abundant biodiversity resources, but there have been management and utilization modes tending toward single species. The abundant biodiversity resources in middle and lower reaches of the Yangtze River are the potential foundations of forestry, as well as a foundation of maintaining the region's sustainable development. The most serious problems involve the single afforested species, that is, monocultures of small plants that can be utilized.

1.3.4 Biodiversity Crisis

Many unforeseen crises may arise with the destruction of biodiversity. The hierarchical structure of biodiversity at the genetic, population, and ecosystem levels is the result of biological evolution over billions of years, which is the natural legacy.

Biodiversity has the external value of offering environmental services of physical material (food, fuel, timber, fiber, medicine, etc.), as well as genetic information and spiritual values, etc. But the destruction of biodiversity and the extinction of species destroy the knowledge stored in the DNA of living cells. With respect to utilizable resources, biodiversity includes natural resources that are the basis of economic development, which can improve the people's material life. Therefore, destruction of biodiversity is a waste of natural resources. From the viewpoint of ecology, nature is a complicated system, which includes different interrelated processes and components. Destruction of biodiversity makes the structure of ecosystem fragile and decreases its function of resisting natural disasters.

1.4 Soil Characteristics and Nutrient Status

1.4.1 Main Soil Types

Because of the long-term influence of geologic activity, the physiognomy and landforms of the middle and lower Yangtze River are very complicated. The main physiognomy consists of mountains, hills, plateaus, and basins. The area of plains is small, and the low mountains and hills account for more than 70% of the whole area. The elevations of mountains in the region of Anhui, Zhengjiang, Jiangxi, and Hunan provinces are between 1500 and 2000 m, and the mountains are formed of granite, rhyolite, sandstone, and limestone. The hill region includes areas in southern Anhui Province, northern Zhejiang Province, the valley and hill area of the Ganjiang River, the hill area surrounding Dongting and Poyang lakes, and basins and hills in the middle of Hunan Province, where the parent materials are sandstone, shale, and Quaternary Period laterite as the core. The plains are alluvial in the middle and lower Yangtze River, as are the plains surrounding the lakes, where the parent materials are alluvium sediment, etc.

There are three main types of soil in the hilly region of the middle and lower Yangtze River: the red and yellow soil of the Ferralsol soil order, yellow brown soil of Alfisol soil order, and purple and lime soil of Lithosol soil order (Xiong and Li, 1987; Li, 1983).

The red earth is distributed in the wide low mountains and hilly region south of the Yangtze River, including the majority of Jiangxi and Hunan provinces, northern Fujian Province, southern Anhui, Jiangsu, Zhejiang provinces, and part of the region of Hubei Province. Of the above hilly regions, the hilly regions of Dongting and Poyang Lakes are the most centralized, where the parent materials are Quaternary Period laterite, sandstone, granite, etc. The red soil is formed under the climatic conditions of the subtropical zone, that is, under a warm climate of adequate precipitation and a long frost-free period. The natural vegetation of the red soil is evergreen broadleaf forest in the subtropical zone. According to the conditions of formation, the process of formation, the fertility, and the characteristics of how the red soil can be utilized, it can be divided into four subordinate kinds of red earth: