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Chapter 13

Ecological Benefits of Italian Poplar Afforestation in Wetland Areas along the Yangtze River, Fanchang County of Anhui Province

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Abstract. In the wetlands along the Yangtze River there are some bank areas where the water usually accumulates, or overflows, about 90–120 days during the rainy season from May to August, and low areas are covered with water all the year. Fanchang County is located on the mid-lower reaches of the Yangtze River in Anhui Province. Within its boundary, there are about 1000 ha of wetlands along the river, associated with eight towns. In 1990, three new varieties of Italian Poplar Tree (*Populus deltoides* cv. (Harvard), *P. deltoides* cv. (Lux), and *P.* × *euramericana* cv. (San Martian)) were introduced to the county, and 64 ha were afforested. By the year 2002, 540 ha had been planted across the county and 28 ha harvested.

This chapter deals with some social, economic and ecological benefits from poplar tree afforestation at wetlands along the Yangtze River in Fanchang County of Anhui Province. Some ecological problems from poplar tree afforestation are also analyzed, and future strategies suggested.

13.1. Introduction

Wetlands have important ecological functions, not associated with other types of ecosystems (Mitsch & Gosselink, 2000; Keddy, 2000). The wetlands along the Yangtze River include the floodplain areas regularly influenced by flood water, and some bank areas along the river. In the rainy season from May to August, the water-table level rises, so that the floodplain and some bank areas are submerged for about 90–120 days. The wetlands along the Yangtze River include three

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components: the embankment swamp, the floodplain areas, and the other mixed types of wetlands. The embankment swamp usually refers to an area always existing between the floodplain and the bank.

The wetlands along the Yangtze River in Anhui Province are associated with several cities including Anqing, Chizhou, Tonglin, Fanchang and Maanshan. The total area of wetlands is about 13,330 ha, of which 8000 ha are floodplain, and 5,330 ha are other wetlands inside the bank (Department of Forestry, Anhui, 2000). Fanchang County is located on the mid-lower reaches of the Yangtze River in Anhui Province. Within its boundary, there are about 1000 ha of wetlands along the river, associated with eight towns. In 1990, three varieties of fast-growing, water-tolerant Italian Poplar Tree (*Populus deltoides*cv. (Harvard), *P. deltoides* cv. (Lux), and *P.* × *euramericana* cv. (San Martian)) were introduced into two towns of the county, and the area of afforestation was 64 ha, which was 0.48% of the total wetland area in Anhui Province. The three fine varieties of artificial breeding are seedling progeny from the free pollination of black American poplar and Euro-American poplar crossbreeded, respectively. They all possess the following characteristics: (1) They are adapted to grow in the warm and humid environment. The average temperature is about 14°C, with sunshine duration more than 1400 h per year and an annual rainfall ranges from about 1200–1400 mm, especially areas along the banks of the Yangtze River; (2) They are cultivated species, with three varieties: photophilic, hygrophilous and oxyphilous; (3) They are not resistant to cold nor wind; and (4) They are readily subjected to attack by pests and diseases. Up to the year 2002, 540 ha had been afforested with hybrid poplar across the county, which is 4.05% of the total wetlands area in Anhui Province (Fig. 1), and by 2001 only 28 ha hybrid poplar had been harvested.

This paper analyzes the social, economic and ecological benefits of afforestation with poplar trees of wetland areas along the Yangtze River in Fanchang County, Anhui Province. In addition, the main ecological problems arising from afforestation with poplar trees are discussed, and finally some sustainable afforestation strategies are suggested.

13.2. The Wetlands along the Yangtze River, Fanchang County

13.2.1. General descriptions

Fanchang County is located on the south bank of the Yangtze River in Anhui Province, 118–118°20′E and 31–31°18′N. It belongs to the northern subtropical and eastern humid monsoon circulation zone. There are about 1000 ha of wetlands along the river, which is 7.5% of that in the province. The wetlands form a strip along the bank, associated with the following towns: Digang, Lunan, Xingang,

Figure 1: The landscape of 36 ha of Italy Poplar trees "*Populus deltoides* cv. (Harvard), *P. deltoides* cv. (Lux), and *P.* × *euramericana* cv. (San Martian)" in the floodplain wetland, Xiaozhou township, Fanchang County, Anhui Province.

Gaoan, Sanshan, Xiaozhou, Baoding and Zhonggou. There are 3400 households and 16,500 residents in the areas along the bank. There are also stands of willows on the floodplain areas outside the bank (Fig. 2). The soil is podzolic, some of which is silty. In its section plane, the topsoil is sandy, about 30–120 cm in depth; the middle layer is discontinuous podzolic silt loam; and the lowest layer is also podzolic silt loam. The composition of the soil is: organic matter, 1.01%; total nitrogen, 0.077%; available phosphorus, 5 mg/kg; available potassium, 60 mg/kg. The nutrients in the soil mainly come from soil eroded by flood water in the upper reaches of the Yangtze River. During the low water season, the plant species in

Figure 2: The wetlands of willow trees along the bank of Yangtze River.

floodplain areas are: *Eleusine indica*, *Alternanthera philoxeroides*, *Polygonum* spp., *Imperate cylindrica* var. *marjor*, *Cyperus* spp., *Caris* spp., *Salix matsudana* Koidz., etc. Species in wetlands within the bank are: *Phragmites communr*, *Micanthus sacchariflоorus,* etc. In the swamps along the bank, the plants are: *Eleocharis* spp., *Phragmites* spp *Micanthus sacchariflоorus*, *Equisetum* spp., etc., and bird species are: *E. garzetta*, *Amaurornis phoenicuru*, *Sterna hirundo*, etc. (Anqing City, 2002).

13.3. Characteristics of Wetlands in the Floodplain Areas

The floodplain is located between the river and hilly land, with a high groundwater level, and is covered by flood water during the growing season. The interactions among the river, the floodplain and other hilly land have formed the following five characteristics:

(1) The floodplain stretches like a belt along the river.
(2) The floodplain wetland is an open ecosystem with different ecological functions; it is neither hilly land nor aquatic ecosystem.
(3) The catchment area in the upper reaches of the river is an important factor influencing the flow volume, flow velocity, and the duration time of floods in the lower reaches. The larger the area of catchment, the greater is the flow volume; and the wider the river, the longer is the duration of the flood. If the flow velocity changes are small, the possibility of flooding is less (An, 2003).
(4) The floodplain is submerged in water for about 90–120 days during the rainy season, from late May to the middle of September.
(5) The species diversity of plants and animals change seasonally.

13.4. Ecological Benefits of Poplar Trees Afforestation

13.4.1. Turning Reed Wetland into Poplar Forests Reduces the Density of Oncomelania hupensis in Floodplain and the Incidence of Schistosomiasis in the Floodplain

In 1990, the government in Anhui Province had implemented a project for "developing forestry and controlling *Oncomelania hupensis* infection". The purpose was not only to enhance wetland ecosystems along the river, and to turn the floodplain into healthy wetland, but also to reduce the density of *O. hupensis* in afforested areas. According to relevant data for the province (Anqing City, 2002; The State Redactal Team of Total Report, 1994), it is

Table 1: The distribution of *Oncomelania hupensis* in Italian Poplar stands in Digang, Xiaozhou, Fanchang County and Xinzhou, Danyang City.

County/ town	Number of investigated cases	Number of living *Oncomelania hupensis* cases	L.R. (%)	Living *Oncomelania hupensis* (averaged density (*O.*/0.11 m^2)	Infected *Oncomelania hupensis* averaged density (*O.*/0.11 m^2)	Afforested period (years)
Digang	281	13	4.6	1.4	0.0006	4
Xiaozhou	290	13	4.4	1.2	0	4
Xinzhou	375	12	3.2	0.7	0	2

L.R. indicates the ratio of the cases with living *Oncomelania hupensis* to total cases; Zhang et al. (1992)

found that the appearance rate of living *O. hupensis*has decreased by about 80%, and the density of living *O. hupensis* by about 88.8%, with the infection rate nearly zero.

In the floodplain along the bank in Fanchang County, the hybrids black American poplar (*Populus deltoides* cv. (Harvard), *P. deltoides*cv. (Lux)), and Canadian poplar (*P.* × *euramericana* cv. (San Martian)) were first introduced to the townships of Digang and Xiaozhou. The floodplain in Digang township and the reed wetlands in Xiaozhou township have greatly improved with regard to afforestation and control of Schistosomiasis. During the flood season, the stand of poplar trees can control the dispersion of *O. hupensis*, and there are no infected *O. hupensis* (Tables 1 and 2).

13.4.2. The Ecological Roles of Italian Poplar in Mitigating Flood

In the rainy season, from May to August, the water table rises in the Yangtze River, and the speed and volume of the water flow is greater, hence its erosive power is also greater. The waves go beyond the floodplain and erode the bank directly, which is a great threat to the safety of the bank. In the past, the peasants who lived along the bank planted willow trees spontaneously every year. One of the purposes for doing so was to provide fuel; another was to reduce the eroding power of the water. So planting Italian Poplar trees in floodplains now reduces wind from the river, and decreases the erosive power of the waves (Table 3 and Fig. 3).

Table 2: The situation for detaining *Oncomelania hupensis* in Italy Poplar stands in Digang, Xiaozhou, Fanchang County.

Dates of investigation	**Places of investigation**	**Investigated plants/cases**	**Plants with *Oncomelania hupensis* cases**	**Total no. of captured living *Oncomelania hupensis***	**Percentage of plants with *Oncomelania hupensis***	**Average density of *Oncomelania hupensis* (*Oncomelania hupensis* per plant)**	**Percentage of infected *Oncomelania hupensis***
	Digang	100	23	41	41	0.41	0
1994.7	Xiaozhou	100	21	35	35	0.35	0
	Control plots	100	56	670	56	6.70	0
	Digang	100	17	21	21	0.21	0
1994.8	Xiaozhou	100	15	16	16	0.16	0
	Control plots	100	43	215	43	2.15	0
	Digang	100	2	2	2	0.02	0
1994.9	Xiaozhou	100	0	0	0	0	0
	Control plots	100	25	38	25	0.38	0

Table 3: Italian Poplar Afforestation in Digang and Xiaozhou, Fanchang County, Anhui Province.

Years	Tree height (m)	Breast height diameter (cm)	Crown extent (m × m)	Branch height (m)	Density (plants/ha)
	Italian Poplar trees in Digang				
1990	3	(3.5)*	–	–	840
1991	4	5.0	1.2 × 1.8	1	830
1996	18	15	4 × 5	3	830
2000	21	19	4 × 5	5	830
	Italian Poplar trees in Xiaozhou				
1990	3.5	(3.5)*	–	–	903
1991	4.2	4.2	1.5 × 1.7	1.7	900
1996	19.5	15.0	4.5 × 5	3.5	880
2000	22.0	20.0	5 × 5	6	800

* indicates the diameter of poplar seedling root.

13.4.3. Protecting the Biodiversity in Wetland Ecosystems along the River

The composition of species in wetland ecosystems was relatively simple. After the afforestation with Italian Poplar trees, the number of species has increased substantially as indicated below.

(1) Main species in the period of high water level: *Oncomelania hupensis*, *Eulota* spp., *Lymnaea*, *E. garzetta*, *Anoplophora chinensis*, *Apriona germari*, *Batocera horsfiedi*;

Figure 3: The edge areas of Italian Poplar forest wetlands eroded by flood water in Summer, 2002.

Figure 4: Winter migrant birds, *Sterna hirundo* rising from the willow forests in the bank of the Yangtze River, Xiaozhou township, Fanchang County.

(2) Main species in the period of low water level:
Birds: *E. garzetta*, *Sterna hirundo*, *Crypsirina* spp., *Passer montanus saturatus*, etc.
Insects: *Anoplophora chinensis*, *Apriona germari*, *Batocera horsfiedi*, *Holcocerus vicarius* (Walker), *Zeuzera coffeae Nietner*, etc. (Hua et al., 1990).
Spiral mollusks: *Oncomelania hupensis*, *Eulota* spp., *Lymnaea*, etc.
Plants: *Polygonum* spp., *Imperate cylindrica* var. *marjor*, *Cyperus* spp., *Caris* spp., *Salix matsudana Koidz.*, *Micanthus sacchariflоorus*, *Rumex acetosa*, *Monochoria vaginalis*, etc.
(3) By afforestation with Italian Poplar in the floodplain wetland, the structure and ecological functions of the wetland have been improved, and the diversity of the species has increased. Meanwhile, these changes had positive effects on enhancing ecological services of wetlands to local social and economic development (Department of Forestry, Anhui 2000) (Fig. 4).

13.5. Social and Economic Benefits

13.5.1. Intercropping to Enhance the Efficiency of Agricultural Landuse

In 1990, there were 64 ha of floodplain afforested in the whole county, of which 62% were in the highlands. During the low water season, the local peasants practised intercropping (wheat, coles, etc.) between the trees. This type of farming not only increases the fertility of arable land, but also raises the income of the peasants.

Figure 5: The raw materials harvested for industrial production from Poplar trees forest with main species of *Phragmites communis*, *Miscanthus sacchariflorus*, *Imperata cylindrica* var. *major*, etc.

13.5.2. Providing Raw Materials for Industrial Production

The Italian Poplar trees have many uses due to the fine quality of their timber. Besides being used as raw material for building and furniture, they can also be used as raw materials for light industry, such as papermaking, fiberboard, and matches. The Poplar trees in Digang were all logged in 2001, producing about 8.5 t/ha. Local peasants can earn RMB 13,500/ha (RMB 100 equals US$ 12), the equivalent of RMB 1,227/ha/year. In addition, until the fourth year, local peasants can obtain 1.5 t of fuel from Poplar forests, which can partly solve the local shortage of energy (Fig. 5).

13.6. Some Problems and Suggestions for Sustainable Afforestation

Some ecological problems have also appeared during recent years, so effective ecological engineering should be implemented in connection with future afforestation as follows:

(1) Podzolic soil is not suitable for retaining nutrients for crop growth, which reduces the growth rate of the trees. According to Table 3, there are two periods of growth at two planting sites: the first period was from 1991 to 1996, and the second was from 1997 to 2000. The data clearly shows that the growth rate in both areas in the second period was much lower than that in the first period. Therefore, it is necessary for us to improve the management of Poplar tree plantation during the second period, especially to enhance the soil fertility.

(2) *Protecting the forests from diseases and pests*. Diseases and pests, especially wood-eating pests, easily attack Poplar trees leading to the destruction of whole forests. Therefore, it is suggested that planters should daub the stems with pesticides two or three times every April and May during the first and second years of afforestation. Thus, the number of pests can be reduced, the quality of the timber improved, and more profit achieved. Meanwhile, protecting birds and reducing the number of leaf-eating pests should also be considered.
(3) For improving plantation engineering, the density of afforestation must take into account the differences in soil qualities and water levels. The density of the trees will influence the density of *O. hupensis*, the water flow volume and the flow velocity during the flood seasons. Thus, an overall adjustment of plantation engineering can be achieved by adjusting the density of afforestation according to the differences of soil and water levels, and the density of afforestation can be changed to 5 m × 5 m per plant, an equivalent of 400 plants/ha. At the same time, intercropping should be implemented during the afforestation in order to increase the productivity of the land.

13.7. Conclusion

Afforestation with Italian Poplar trees on the floodplain wetlands along the Yangtze River has produced great ecological benefits in recent years, which include: (1) Reduction of the density of *O. hupensis* in the shallow areas, and the incidence rate of Schistosomiasis; (2) Mitigation of floodwater from the Yangtze River in the rainy season. (3) Italian Poplar forest wetlands along the Yangtze River have increased biodiversity in the floodplain areas. Economic benefits have been achieved, so that Digang township has now harvested 28 ha of poplar timber, with profits of RMB 13,500/ha in 2001. This ecological engineering of wetlands in Fanchang County of Anhui Province has contributed to the transformation of local wetland ecosystems, so that they can now be managed for sustainable development and local socio-economic progress.

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References

An, S. Q. (2003). *Wetland ecological engineering*. China Chemical Publishing House, Beijing.

Anqing City, Anhui Province. (2002). *The Total Planning and Designing of Waterfowl Protected Zone in the Wetland Areas Along the Yangtze River* (pp. 23–26). Anhui, Anqing.

Department of Forestry, Anhui Province. (2000). 95, Summary *Developing Forestry and Controlling Oncomelanias Propagation Engineering* (16 p.). Anhui, Hefei.

Hua, B. Z., Zhou, Y., & Fang, D. Q. (1990). *The Cossid fauna of China (Lepidoptera:Cossidae)*. Tianze Publishing House, Shanxi Yangling.

Keddy, P. A. (2000). *Wetland ecology principles and conservation*. Cambridge University Press, Cambridge.

Mitsch, W. J., & Gosselink, J. G. (2000). *Wetlands*. Van Nostrand Reinhold Company, New York.

The State Redactal Team of Total Report. (1994). *The planting of action to protect of China biodversity*. China Environmental Publishing House, Beijing, pp. 1–9.

Zhang, J. K., Song, H. T., & Li, L. G. (1992). Effect of reforestation on Oncomelania snails. *Journal of Anhui Agricultural University*, **19**, supplement, 49–51.