Poplar Genetic Conservation and Use in China, with Special Attention to North China

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China has a distinctively rich flora of the Salicaceae, and in particular of poplars. Fifty three species have been described in China while 37 are distributed in North China[1]*. Poplars, mainly as hybrid clones, are widely planted in the central and northern parts of the country for a variety of purposes. While poplar plantings have a marked protection function in North China, where they are the main constituent of a large shelterbelt grid presently being established, commercial forests for wood production make up most of the poplar stands in central and eastern China. The country's unique genetic poplar pool is thus widely used for tree improvement, but the few remaining natural forests are locally under anthropic pressure. Several papers have stressed the need for their systematic conservation. Research on poplar improvement and cultivation is giving high priority to the use of biotechnology applications, and China is the first country in the world where genetically modified (poplar) trees have been released in commercial, large-scale planting programmes. The health and proper utilization of the genetic resources pool will determine the sustainability of poplar cultivation in the country, as this paper describes.*

Poplar Distribution and Use

China has a distinctively rich flora of the Salicaceae, and in particular of poplars. Out of 100 and more Populus species reported in the world, 53 have been described by Chinese authors (Xu, 1988; Zhao & Cheng, 1994), and 37 are distributed in North China[2] *(Ibidem; see Table 1), although the precise taxonomic status of some species, sub-species or varieties may be unknown Poplars have for centuries been closely associated with human activities and extensively used in agroforestry or silvopastoral systems in China. As a result, the overall present distribution of poplars, including native species, differs considerably from the natural distribution areas. Before 1950, native poplars and willows had been planted extensively in Central and North China, along roads, channels and railway lines, using local sources (Zheng & Ren, in Zhou & Weisgerber, 1997). In the 1950's and 1960's, soil conservation and rehabilitation were given high priority in the Northeast and in central Inner Mongolia, and public campaigns promoted the protection of agricultural fields, grazing lands, cities, villages and houses by green shelterbelts. These initiatives resulted in systematic plantation programmes of woody networks along streets, roads, fields, canals and railways, and in home gardens. The unique features of black and balsam poplars (high capacity for vegetative propagation, fast initial growth and availability of reproductive materials locally) made them widely popular. Vegetative propagation was commonly used for native poplars, complemented by collection and exchange of seed when the amounts of local materials were insufficient. Large quantities of seed (P. simonii and P. pseudosimonii) were collected in the 1960's in central Liaoning and forwarded to forest farms in the North-eastern Plain. Seedlings were then culled in nursery and plants rapidly installed in the field. Little concern was reported regarding germplasm provenance, matching species or clone to site, or even tending practices after planting.*

[1] In this paper, North China will refer to the area covered by the Three North Shelterbelt Development Programme (Three North Bureau, 1989), described in the Box on p. 5.

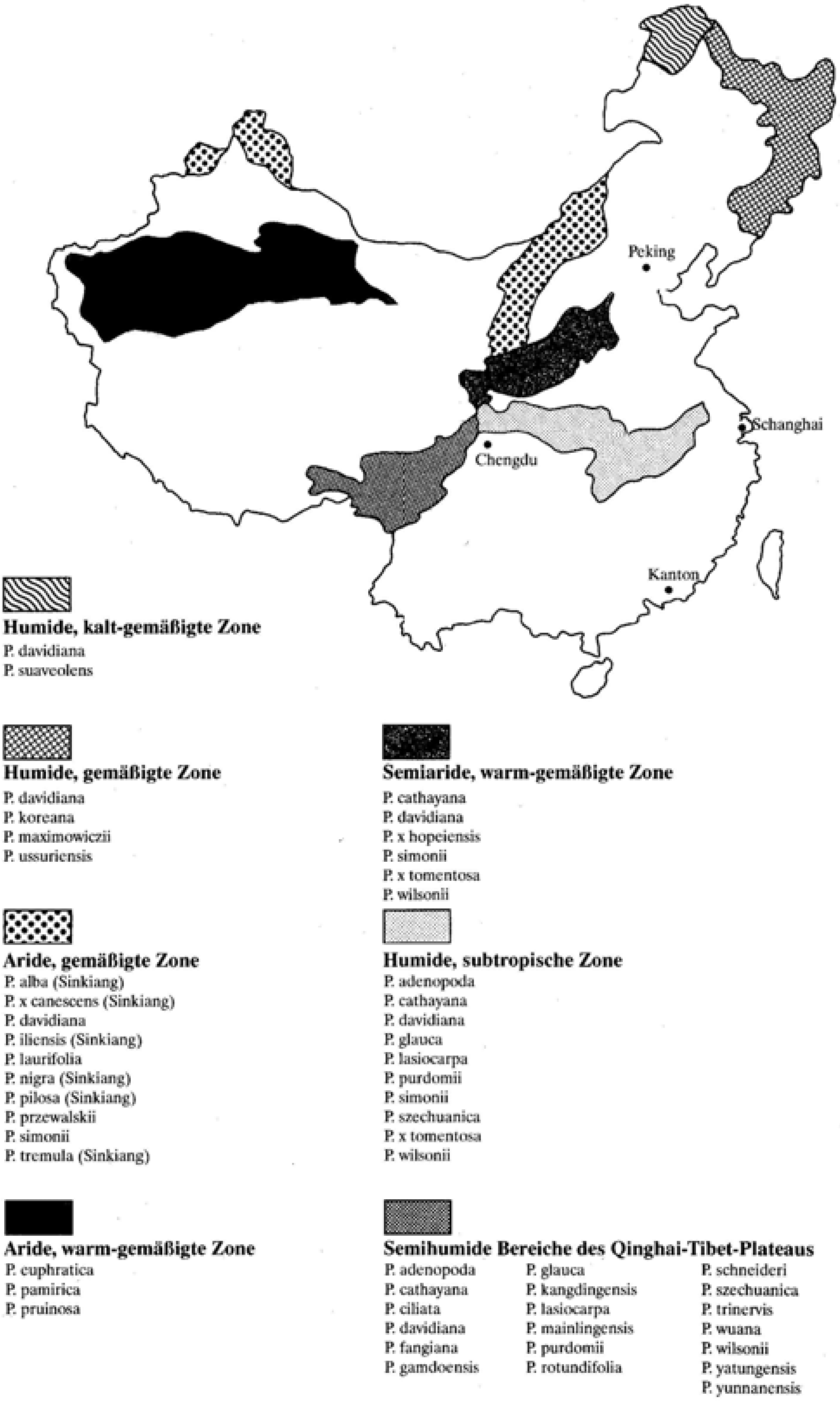

Abbildung 1

Klimabezogene Zuordnung natürlicher Pappelvorkommen in China

Classification of indigenous poplar species of China in respect to the climatic zones

Figure 1: Natural distribution of native poplars in China, according to climatic zones (from Weisgerber, in Zhou, Hong & Weisgerber, Horst, 1997)

SPECIES	North East			Central North			North West					ALTITUDE (m)
	Heil	Jil	Liao	Mon	Heb	Shan	Shaa	Gan	Nin	Qing	Xinj	
P. afghanica											√	1400 - 2800
P. alba											√	450 - 750
P. amuyensis	√			√								600 - 800
P. canescens											√	600 - 700
P. cathayana			√	√	√	√	√	√		√	√	800 - 3200
P. charbinensis	√											300 - 500
P. davidiana	√	√	√	√	√	√	√	√	√	√	√	200 - 3800
P. euphratica				√				√	√	√	√	2500 - 2900
P. gansuensis								√				1800 - 2000
P. girinensis	√	√										300 - 400
P. hopeiensis					√	√	√	√	√	√		700 - 1600
P. hsinganica	√			√	√							300 - 700
P. iliensis											√	600 - 750
P. jrtyschensis											√	200 - 2000
P. koreana	√	√	√									400 - 1100
P. lasiocarpa							√					1300 - 3500
P. laurifolia											√	1200 -1700
P. maximowiczii	√	√	√	√	√		√	√				400 - 2000
P. nakaii	√	√	√	√	√							600 - 900
P. nigra											√	400 - 800
P. ningshanica						√	√					600 - 1000
P. pamirica											√	1800 - 2000
P. pilosa											√	1600 - 2300
P. pruinosa											√	300 - 1500
P. przewalskii				√			√		√			500 - 1500
P.pseudomaximowiczii					√		√					1000 - 1600
P. pseudosimonii	√	√	√	√	√	√	√	√		√		300 - 2300
P. pseudotomentosa						√						300 - 1400
P. purdomii					√		√	√				700 - 3300
P. simonii	√	√	√	√	√	√	√	√	√	√	√	600 - 2300
P. suaveollens	√			√								200 - 400
P. szechuanica							√	√				1100 - 4000
P. talassica											√	500 - 1800
P. tomentosa					√	√	√	√				200 - 1800
P. tremula											√	700 - 2300
P. ussuriensis	√	√	√									300 - 1400
P. wilsonii							√	√				1300 - 3300
NUMBER BY PROVINCE	12	8	8	11	11	8	14	12	5	6	16	37

Legend: Heil: Heilongjiang; Jil: Jilin; Liao: Liaoning; Mon: Inner Mongolia; Heb: Hebei; Shan: Shanxi; Shaa: Shaanxi; Gan: Gansu; Nin: Ningxia; Qing: Qinghai; Xin: Xinjiang

Table 1: Distribution of poplar species in North China (Based on Xu*, 1988)*

While showing good growth under the best conditions, and in home gardens, the performance of native poplars in North China was overall merely satisfactory. Considering the large amount of resources devoted to these early large-scale planting campaigns, survival rates of young saplings were below expectations. In the most difficult plantation sites, surviving plants have become known as "small old trees". In the meantime, valuable and unique experience was gained on nursery and planting techniques, natural distribution and ecological requirements of native stock.

Forest scientists and breeders also contributed to translating the high political commitment to reforestation into action. They first concentrated on the importation of foreign germplasm. Introduction of exotic poplars had taken place in the past, including P. nigra var. italica and P. nigra var. thevestina, P. x canadensis, and P. deltoides (which hybrids have locally been known in coastal Hebei as P. x shanhaiguan since the 1900's), although their use was limited to amenity planting in towns and botanical gardens (Zhang Jie & Zhang Qi Wen, in Zhu & Zhang, 1991). P. nigra growing in western Xinjiang is even reported to have been introduced by traders along the Silk Road in historical times. An arboretum was established in Gaixian, Liaoning, in 1930, comprising several poplar species.

Systematic introductions were initiated only after 1949. From 1950 to 1960, approximately 60 clones were imported by the Chinese Academy of Forestry and the Botanical Garden in Beijing, from East Germany, Poland, Romania and the former USSR. In early 70s, clones such as I-214, Pioneer, Polska-15, Robusta, Ruskii, Sacrau-79, Serotina and Stalinetz, along with few varieties of P. x canadensis, P. x berolinensis, P. laurifolia and P. nigra were available in China (Zhang and Zhang, 1981).

The early breeding and planting programmes

Availability of new germplasm and expectations of potential heterosis in hybrid progenies (F1) were driving forces in the development of dynamic poplar improvement programmes. One of the first pollination trials was reported on white poplar P. tomentosa by Prof. Xu Weixin in 1947 (Zhang & Zhang, 1981). It was followed by several activities undertaken by the Chinese Academy of Forestry, Nanjing Forestry University, and other research institutions, until the early 70's.

Several combinations were tested in controlled crosses, including P. nigra x P. simonii or P. simonii x P. nigra (later released under the names of P. x simonigra, P. x xiaozhuanica, P. x opera, P. x popularis, P. x simopyramidalis, P. nigra x P. cathayana (P. x beijinensis), and many other species, varieties and clones. A summary of the work carried out by the poplar research Institute of Gaixian, Liaoning, is detailed in Zhang & Zhang, 1981. Some selection programmes, for example in Baicheng Forestry Institute, Jilin, or in railway nurseries, also used mass selection of bulk seed from open pollination collected from P. simonii mother trees, which progenies displayed vigorous hybrid seedlings. Seed was then sown in the nursery or greenhouse, seedlings were culled on the basis of vigour and frost resistance, and families were tested in the field. As a result, several hybrids displaying valuable features such as straight stem and fast initial growth, compared with native balsam poplars, were produced. In the conditions of North China, the most promising combinations included P. simonii x P. nigra, P. cathayana x P. nigra, and P. pseudosimonii x P. nigra.

These early programmes were carried out in an empirical way, using mainly gene sources available locally, and relying on few parent trees. It is suspected that the genetic base of the new materials was very limited and several clones were closely related (see Table 2). The need for a rational approach to poplar improvement, *starting with systematic exploration, collection and evaluation of parent trees, was progressively recognized and exploration and conservation activities initiated for P. nigra in Xinjiang and P. simonii in Jilin by the Baicheng Forestry Research Institute.*

Results of, and information on, the selection and propagation work carried out by scientists in the 1960's and 1970's were progressively passed to forest managers and technicians. However, many research activities, including tree improvement, and several plantation programmes were drastically reduced or abandoned during the Cultural Revolution. The period also saw a surge in felling and deforestation following the Great Leap Forward policy. In North China, dramatic increases in human population also contributed to the worsening environmental damage.

Developments since 1980's

Scientific work was reactivated in forestry academies, universities and research institutions after the Cultural Revolution, in the late 70's, at a time when political commitment again emphasized the need for large-scale mobilization of efforts and resources to combat desertification, improve or restore agricultural capability and increase wood production. Several national, regional or local programmes were launched, and a specialized agency in charge of reforestation in arid areas, the Three-North Shelterbelt Development Programme was established within the Ministry of Forestry[3]*.*

The Three North Shelterbelt Development Programme

Since its establishment in 1978, the Three-North Shelterbelt Development Programme of the Three North Bureau (Sanbei in Chinese) has initiated and coordinated a systematic plantation programme carried out through state, provincial/regional and local forestry authorities. Reporting to the State Council, the Programme encompasses 551 counties/districts/cities of 13 provinces, autonomous regions and municipalities in north-west, central north and north-east China covering 4.069 million square kilometres or 42.4% of the country's total land area. This world's largest ecological programme commenced in 1978 and should be completed by 2050, with a planned programme area of 35.08 million ha, including 23.03 million ha of plantations.

By 1994, over 13 million ha had been planted under the first and second phase of the programme. During 1996 – 2000, the objective was to plant 6.18 million ha. and 4.04 million ha between 2001 – 2010. The programme now aims at increasing the quality and marketability of the wood produced and enhancing economic benefits from the plantations.

Other major forestry-related programmes include Shelterbelt Development Programmes along the Liaohe, Yangtze and Yellow rivers, The Plain Afforestation Programme, the Taihang Mountains Afforestation Programme and the National Programme to Combat desertification (Shi et al, 1997). Most programmes are located in North China.

Poplar remains the main afforestation genus. Out of 33 million ha of artificial forest in China, the area covered by poplar plantations is estimated to be 6.7 million ha (including commercial and protection forests). In the Three North Shelterbelt Programme and the Plain Afforestation Programme, poplar is reported to be 60 % of the total area of trees planted (National Poplar Commission, 1996). 80 % of wind-break

[3] The Ministry of Forestry was replaced by the State Forestry Administration in 1998.

shelters of the Three North have been planted with poplar (Han & Grosscurth, in Zhou & Weigerber, 1997).

To achieve its ambitious goals, the Three North Programme, in the line with other similar projects, identified genera, species and varieties which had proven their adaptability and reliability in Northern China. In site types where shallow groundwater was available (lowlands and basins, sandy lands, loess plateaux, but also sandy dunes), priority was given to poplar, especially to those clones obtained in the 1950's and 1960's, for which the selection process had been completed. In the most difficult sites devoted to poplar cultivation, hybrids P. simonii x P. nigra were selected on the basis of local experience.

The country's new policies of opening to the outside world reactivated exchanges in the poplar breeders community. China formally joined the International Poplar Commission in 1980. Increased contacts resulted in the introduction of an unprecedented amount of foreign poplar germplasm (several hundred accessions were recorded; by comparison, only 80 clones were imported in the 70's, from Italy and Yugoslavia) including southern provenances of P. deltoides, a wide collection of P. x euramericana from Western Europe, and several P. deltoides x P. trichocarpa Belgian accessions.

Since the early 1980's, much research work undertaken by forestry academies and universities has focused on importing, evaluating and screening exotic poplar materials (mainly in form of clones already selected abroad), and testing their combining ability with local poplars or their hybrids. Strong heterosis and even greater potential has been found in P. deltoides x P. cathayana families, displaying good adaptation in the conditions of Central China (Tong and Han, 1991).

Activities carried out in continuation of the breeding work of the 1960's and early 1970's for North China appeared drastically reduced. A range of P x euramericana "Zhonglin" and other "ZJ" and "ZX" hybrids were obtained in the end of the 1970's in Beijing. P. x popularis clones were crossed with a variety of exotic germplasm (including Polska-15 and various clones of P. nigra and P. deltoides) in 1983 and the potential for greater genetic gain was uncovered. Results of several recent comparative trials in North China confirmed that few foreign clones performed better than P. simonii x P. nigra hybrids in the best sites (Wang, 1995). A large-scale evaluation of the performance of poplar plantations in China was carried out on 23 clones and resulted in a typology for poplar growing in the country (Chen, Zhao, Xu & Yang, in Wang, 1995). Work has also been carried out on white poplars (Leuce section) which locally have displayed good site adaptation and low incidence of pests. Technical difficulties to easily propagate them vegetatively, have, however limited their use in large-scale afforestation schemes. The overall gap in the continuity of breeding programmes in the 70s explains why few new clones have been released for North China, and why most afforestation schemes still rely on poorly diversified stock nowadays (see Table 2).

Generic Name	*Parent Trees (F x M)*	*Number of Accessions**	*Year of Creation*	*Area Planted (ha)*	*Number of Trees Planted*
P. x popularis	*simonii x nigra*	*10*	*1956*	*1,000,000*	*51 million*
P. x beijinensis	*cathayana x nigra*	*13*	*1954 - 1957*	*66,000*	*200 million*
P. x xiaohei	*simonii x nigra*	*-*	*1960*	*1,000,000*	*-*

**: number of different, although closely related, genotypes, (alleged half-sibs or full sibs).*

<u>Table 2: </u> Three successful poplar clonal lines used in afforestation programmes in North China (From Zhu & Zhang , 1991).

In North China, early man-made stands comprising native poplars P. simonii and P. pseudosimonii, elms, oaks or pines, have long reached their age of exploitation and are being replaced by hybrid poplar stock. All over North China, the genetic diversity of new poplar stands is often limited to a single clone (mostly the hybrid P. simonii x P. nigra). The original infusion of P. nigra traits into the local gene pool has allowed foresters to widen the ecological range covered by native P. simonii, P. pseudosimonii and P. cathayana, towards drier sites outside riverbeds and valleys. However, poor silvicultural management (high density, careless pruning), and recurrent extreme climatic events have recently contributed to weakening poplar stands growing in the most difficult environmental conditions.

Few continuing breeding programme are closely associated with poplar forestry in North China, but the situation is different in Central China. In south temperate central areas of China (from latitude 30º to 35º N), several euramerican poplars introduced from Europe display good growth along extensive river floodplains and have become a major component of a highly productive agroforestry system since 1980s, where the private sector is the driving force

The high value and scarcity of wood in the central and eastern plains provide a strong incentive for a greater expansion of high-yield poplars, and cultural systems developed by breeders and scientists are rapidly adapted by farmers. However, genetic diversity in plantations is still extremely limited: the Genetics Group at Nanjing Forestry University estimates that about 60 percent of the plantings in Central China, an area of roughly 600,000 square kilometres, today consist of clone I-69 introduced from Italy (Farmer, 1992).

With the assistance of several institutions, including the Chinese Academy of Forestry and Nanjing Forestry University, breeders and forest managers are working to broaden the genetic base of the plantation programme. The area is climatically similar to the lower Mississippi Valley, and several missions of exploration and collection by Chinese breeders in southern USA have lead to the establishment of a diverse pool of black cottonwood accessions which now serve as base collections. Since 1980, Nanjing University scientists have also engaged in a breeding programme using i.a. P. deltoides and native P. simonii from Central China.

Modern Biotechnologies and Poplar Improvement

Biotechnology tools have increasingly been used in forestry in China, although at a slower pace than the agricultural sector. Poplars have been used as model species using a number of modern biotechnologies, for the characterization of the resource, for early testing, and in tree breeding. Capacity-building in poplar genetic modification has been initiated in the framework of a UNDP-funded development project (UNDP/FAO, 1994-1998). The project assisted poplar scientists at the Chinese Academy of Forestry in transferring a single toxic gene of Bacillus thuringensis into several varieties (including a P. nigra) to confer resistance to gypsy moth. Trial sites of transgenic poplars were established in Xinjiang, Northwest China, in 1994. Since then, work is being continued in various institutions to generate borer-resistance and investigate tolerance to several factors, including salinity (Wang, 2003). Interestingly, China is the only country in the world where genetically modified (poplar) trees have been released in commercial, large-scale planting programmes. Table 3 shows the state of genetic modification in poplar in China in 2003.

Poplar species or clone	*Research (R), Field testing (F), Environmental release (E), or Commercial planting (C)*	*Traits targeted*	*Gene(s) inserted*	*On going or Applied for*
Poplar hybrid 741 [P. alba x (P. davidiana + P. simonii) x	*E C*	*Resistance to leaf-eating insects*	*Bt Cry1 and API*	*Applied for Commercial plantings in 2001*
Populus deltoides	*R*	*Insect resistance*	*Bt*	*On going*
Populus deltoides x P. cathayana	*R*	*Resistance to leaf-eating insects*	*mtiD/gutD*	*On going*
Populus deltoides x P. simonii (N-106)	*R*	*Resistance to leaf-eating insects*	*AaIT*	*On going*
Populus nigra	*E C*	*Resistance to leaf-eating insects*	*Bt*	*Applied for commercial plantings in 2002*
Populus simonii X P nigra.	*R*	*Salt resistance.*	*Bet-A*	*On going*
Populus tomentosa	*R*	*Resistance to disease and stress*	*NP-1 (rabbit alexin)*	*On going*

Table 3, Summary of the state of genetic modification in poplar trees in China

It should be noted, however, that linkages between traditional tree breeding and improvement programmes, and biotechnology applications, have been weak. In particular, the best poplar genetic material collected and selected by traditional *breeding programmes, have not always been used in biotechnology applications. There is therefore a gap between programmes, and a lack of transmission of knowledge. Research is too often undertaken on biotechnologies, including genetic modification, without a supporting tree improvement programme. As a result, much work on genetically modified (GM) trees stops at laboratory stage without practical applications. Advances in biotechnologies have already an impact on access and benefit sharing: scientists who have developed an GM "741" poplar at the Agricultural University of Hebei and the Institute of Microbiology, Chinese Academy of Sciences have applied for breeder's rights for a new plant variety. It will be the first case, if their application is approved, to be granted intellectual property for a GM forest tree in China.*

Poplar Forest Health and Biosecurity Issues

The greatest hazard to the unique, large-scale Chinese poplar plantation effort (which relies on a limited number of genotypes) lies in the concomitant risk of pest and disease outbreaks. The number of insect pests recorded on poplar is more than 200 in China, and their impact has increased dramatically in the last decades as poplar plantations have extended. The damage caused by tree borers is the most serious threat to commercial and protection forest. To control the spread of longicorns like the Asian long-horned beetle Anaplophora glabripennis, (see Box) 24 million trees were reported cut and burned in Ningxia, North Central China, in winter 1991 and spring 1992 (National Poplar Commission, 1996). The incidence of poplar diseases is reported low in North China, compared to Central China, allegedly in connection with harsh winters and dry autumns and springs unfavourable to fungal propagation (Schmutzenhofer, et al. 1996). While integrated pest management techniques are being promoted, there is also a growing awareness that selection of planting material for insect and disease resistance is of vital importance for the sustainability of large-scale monocultures. Traits relating to tolerance/resistance to biotic factors have increasingly been taken into account in poplar improvement and genetic modification programmes.

A special threat to poplar stands: the Asian Longhorned Beetle

The Asian Longhorned Beetle (ALB) Anaplophora glabripennis, is endemic in China infesting hardwoods. The larval is the most destructive stage, when tunnels are bored under the bark and through the wood. After pupation the adults emerge by boring a tunnel in the wood and creating a round exit hole; the damage to the tree is significant. Each female is capable of laying 30 to 70 eggs.

Since 1998 the damage caused by the Asian Longhorned Beetle in North China has become critical due to severe climatic stresses on the trees, and the increasing reliance on single tree species/clones plantations. The insect pest is now distributed in 240 counties of 13 provinces in the Three North Region i.e. Shaanxi, Gansu, Ningxia, Qinghai, Xingjiang, Beijing, Tianjing, Hebei, Inner Mongolia, Shanxi, Liaoning, Jilin, Heilongjiang. At this time the tree genera most affected in the Three North Region are mainly poplars, willows and elms, which make up the core of the broadleaf species used.

In Ningxia Hui Autonomous Region, the worse affected province, from the end of 1980s to the beginning of 1990s, the Asian Lonhorned Beetle has spread to over 200 townships of 20 counties and the infested areas have increased from 2,000 ha to 40,000 ha. In order to control this situation, the regional Government has removed more than 24 million infested trees, including poplars, willows and elms, so that the protective forest network for agriculture is no longer functioning. A new forest network was established with alternative tree species more tolerant to the borer.

However, there are significant constraints to planting these trees, because they are not so well adapted to cold, arid areas and diseases and they give a lower economic return. Farmers thus prefer to plant poplars following traditional practices. The current situation indicates the potential for further spread into west and northern parts of China including into the remaining natural forests. The pest is also a global threat, with serious impacts on international trade.

Recent projects on poplar genetic resources in Northern China

Decision-makers and foresters have become increasingly aware of the dimensions of the challenge, and various initiatives launched towards ensuring the sustainability of poplar plantation forestry in North China. Action has concentrated in two directions: (i) getting a better knowledge of remaining native stands and species and their genetic diversity, and subsequent explorations and collections; and (ii) making efforts to diversify artificial forestry, both by increasing species diversity and poplar material genetic diversity. Several papers have stressed the need for a systematic conservation plan for native poplars (Xu, 1988; National Poplar Commission, 1996; Weisgerber, 1995).

The issue has been addressed through various initiatives promoting a better utilisation of the indigenous material. Regular exploration and collection missions were carried out in 6 provinces and regions from 1985 to 1987 (Han, Wu & Wang, in Zhu & Zhang, 1991). In 1987, a country-wide exploration of P. cathayana was commissioned by the Ministry of Forestry to the Chinese Academy of Forestry (Li and Yang, 1997). At the same time characterisation of the diversity among provenances of P. ussuriensis was initiated. An extensive survey of the botany, distribution, ecology, utilization and potential of P. euphratica resulted in a monograph providing a wide coverage of Northern China (Wang, 1996).

A Chinese-German cooperative project begun in 1984 carried out much exploration work, particularly in Northwest China. 650 native and 170 exotic poplar accessions (including 22 clones of P. simonii and 230 clones of P. cathayana) have been collected and stored in ex situ stands in Shanxi. Intraspecific and interspecific controlled crosses were carried out on 400 different combinations (1984 – 1995) concentrating on white poplars and northern balsams. Large amounts of new germplasm are still under investigation in the field, after the project completion in 1997 (Weisgerber, et al. 1995).

A Belgian-sponsored project, situated in the eastern part of Inner Mongolia, has from 1991 to 2002 undertaken exploration and conservation of native poplars, including P. simonii and related varieties, a poplar selection and breeding programme, and gathered over 652 domestic and foreign poplar clones for conservation and evaluation. The project's investigations have confirmed previous results on the high breeding potential of P. simonii in North China. The species appears to rank first among cold harsh and drought tolerant native poplars, and its variability over a vast distribution range is under investigation. Additional genetic gain in combination with P. nigra and P. deltoides could probably be easily obtained through a careful selection of parent trees and recurrent selection. In addition to working on P. simonii, the Belgian-Chinese Afforestation project also engaged in the introduction of documented materials of black poplar from Xinjiang (P. nigra) and cottonwood (P. deltoides) from northern USA and the Canadian Prairies.

In Central and Eastern China, where commercial forestry is more profitable, there has been in recent years a renewed interest in poplar plantation, boosted, to an extent, by the release of clones obtained through modern biotechnologies (tissue *culture or genetic modification), and marketing campaigns from biotechnology companies. It should be noted, however, than traditional breeding and relevant upgrades in cultivation practices alone can provide a significant increase in the productivity of the poplar plantations: the Forest Resources Development and Protection Project (1996-2001) under the World Bank Loan Programme, facilitated the establishment of nearly 1.3 million ha of high yield poplar (mainly euramerican hybrids and white poplars). The project relied on improvement gains in productivity through use of better clones and silvicultural management. Its objectives (average annual increments increased from 15 cubic meters per hectare to 20 m^3/ha; and rotations shortened to 5-6 years for pulpwood, and to 12-14 years for veneer) are, according to the latest growth rates assessments, likely to be met.*

Conclusion

Afforestation programmes were launched in China in the 1950's and intensified since 1978 have contributed to the establishment of an extensive network of stands and shelterbelts to provide wood, fuelwood, fodder and basic materials, reduce soil erosion and desertification, and support agriculture and animal husbandry. The importance of man-made forests for the provision of a wide range of goods and services is likely to grow in the future. Domestic supplies of timber and wood are likely to depend even more on plantation forestry since a country-wide ban on logging in remaining natural forests has been implemented in 1998. The Chinese government has shown a strong commitment to conserving biological diversity and to combating desertification, in which plantation forestry is a major element. Plantation forestry is increasingly driven by the private sector and economic considerations. Even in North China, public plantations programmes are required to yield direct economic return.

Originally using a short list of indigenous species and varieties, including native poplars, and paying limited attention to the genetic quality of the materials, plantation programmes have become more sophisticated and rely nowadays on a few selected species and clones from which higher outputs are expected. Poplar is at the core of modern man-made lowlands forestry and a key element in rural economic development, and there are few alternative to the genus.

The unstable genetic structures of some poplar plantations have nevertheless already lead to severe disease and insect damage and to considerable production losses in several parts of the North. The limited number of clones available for large-scale programme, and their narrow genetic base, demonstrate the need for continuity of poplar improvement in North China to ensure long-term sustainability of the genetic gains obtained so far. Such programmes are also necessary for a proper utilization of, and to optimize outputs from, genomic technologies that are being applied to the forestry field.

At the same time, a prerequisite for a sustainable programme is the maintenance of a wide genetic base for breeding and selection work. The experience gained in China demonstrates the importance and uniqueness of the native genetic stock, not for planting purposes, but for infusion in customized and tailored breeding plans. Since native gene pools are rapidly decreasing, urgent actions are required locally for P. cathayana, P. euphratica, P. nigra and P. simonii in their respective areas of distribution.

Introduction of poplar clones developed in other countries under different conditions complement long-term national breeding efforts. In Central and Eastern China, exotic poplars and their hybrids with native stock make up the majority of poplar plantations. In North China, few exotic clones have proved adapted, and the *main interest of foreign poplar germplasm lies in its recombination ability with native resources, after the adaptation of parent trees (from northern, continental provenances) has been assessed. Among the best candidate parents are P. nigra, P. deltoides and P. simonii.*

The challenge is at the size of the country, and several initiatives have already begun to address the issues of conservation and poplar improvement. The work should be continued with a sense of long-term perspective and benefit from strong political commitment. Raising awareness of the importance of productivity gains to be reaped, through sustainable genetic management programmes, is a critical issue.

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