

TREES AND URBAN FORESTRY IN BEIJING, CHINA

by George V. Profous

Abstract. Management practices, nursery production, public preferences, historical development, and land use all influence species composition, diameter size and forest distribution in Beijing, China. Four genera (*Populus*, *Sabina*, *Sophora* and *Robinia*) comprise almost 55% of the trees inventoried. Since 1949, the greenspace cover of Beijing has increased dramatically due to a significant commitment by the municipal government. Older trees surviving from earlier planting eras are found off-street, primarily in older residential and institutional areas. Research is directed toward the use of trees for economical temperature, wind, and pollution control, as well as for aesthetic reasons. Legislation to protect old and historic urban trees was introduced in 1990 to supplement the informal regulations managed by the Bureau of Forestry and the Institute of Landscape and Gardening. Public support for tree preservation and planting is strongly rooted in Chinese culture and tradition.

Urban forest composition is influenced by human preferences, sequence of occupancy, available plant materials, urban morphology, natural factors, and human management systems (8). The purpose of our research is to begin describing the structure and selected management of the Beijing urban forest. Urban forests are increasingly valuable in their influence on the quality of life in a rapidly urbanizing world. By studying urban forest values and use in cities with divergent cultures and histories, similarities or differences may provide new management insights and important clues to human preferences and behavior.

Location

Beijing is ringed to the north and west by mountains up to 3,000 feet high (900 m). The metropolitan area covers 16,800 km² and is more than 60 per cent mountainous. The city's central urbanized area is 154 mi² (400 km²), part of a larger Central City Planning Area of 290 square miles (750 km²), home to over 9.2 million people. The urban area lies between 100 and 130 feet (30 and 40 meters) above sea level. The Taihang Mountains on the easterly edge of the plateau of loess

(loamy material deposited by the wind) separate Beijing from the Gobi Desert to the northwest.

The climate is roughly similar to Kansas/Nebraska except that winters have relatively little rain or snow. Beijing is in the temperature zone with a continental monsoon climate. Precipitation is concentrated from June to September when warm and humid air from the southeast reaches Beijing. Rainfall averages between 20 and 40 inches in the plain, but drops to as low as 10 to 20 inches in the mountains (5).

Cold and dry Siberian winds sweep across the Mongolian Plateau from October to March bringing sand and silt across the mountains from the Gobi Desert. Rapid urbanization, warmer temperatures, drier years, and possible long-term climatic change are placing western Beijing in danger of desertification (Yu, pers. comm.). The winds are also strongly influenced by the mountainous topography, with air flows southerly during the day and north-northwesterly at night. Wind reduction is considered more important than maintaining airflows from the mountains into the city despite air pollution problems.

Beijing's 3000-year development history is linked to its strategic location at the northern edge of the North China Plain, along the mountain passes used as trade routes from the Mongolian Plateau, Manchurian Plain, and Central Asia. Beijing retains the underlying structure of many older Chinese cities: a central enclosure for a royal family and nobility, a historic center surrounded by walls and moats, and a grid of streets going north-south and east-west.

Tree History

Beijing is situated within a deciduous broadleaved forest. Centuries of overcutting throughout China has resulted in a forested area of 1/3 acre (0.13 ha) per person (or about 1/10 the

ratio in the United States) (4). The vegetation of the metropolitan area includes many genera similar to those of the United States, including *Liriodendron*, *Sassafras*, *Magnolia*, *Acer*, *Cornus*, *Rhododendron*, *Liquidambar*, *Viburnum*, and *Hamamelis* (2).

A forest steppe is found in the drier mountains of western Beijing. The original cover of the North China Plain may have been grassland, wooded steppe, or forest (7), but Wang (9) concluded that the area was forested. Many forest species, once widespread, have been displaced by high population pressures and are now found only in the mountains. Many species, including Peking willow (*Salix matsudana*), weeping willow (*S. babylonica*), Simon poplar (*Populus simonii*), and white poplar (*P. alba*), observed in street plantings, plantations, and semi-natural stands have been in the area since the 3rd century A.D. (9).

Some major introduced urban species are black locust (*Robinia pseudoacacia*), London planetree (*Platanus acerifolia*), white poplar (*Populus canadensis*), and eastern cottonwood (*P. deltoides*) (2,10). The percentage of introduced species is low, although it was somewhat higher three decades ago, because of large plantings of exotic poplars and black locust.

Species Composition and Distribution

We identified more than 90 trees and shrubs in twelve neighborhoods as part of a study of the structure and management of the city's forest (Fig. 1) (6). *Populus*, *Sabina*, *Sophora*, and *Robinia* comprise almost 55 percent of all trees. Another 24 percent is made up of Siberian elm (*Ulmus pumila*), maidenhair tree (*Ginkgo biloba*), Shantung maple (*Acer truncatum*), tree-of heaven (*Ailanthus altissima*), paniced golden-rain tree (*Koelreuteria paniculata*), lilac (*Syringa* spp) Peking willow (*Salix matsudana*), ash (*Fraxinus* spp.), paulownia (*Paulownia* spp), pine (*Pinus* spp.), silktree (*Albizia julibrissin*) and sycamore (*Platanus orientalis* and *P. acerifolia*). Shrubs make up 18 percent of the urban forest.

Throughout the 1940's and 1950's, Lombardy poplar (*Populus nigra* var. *italica*), black poplar (*Populus nigra*), Carolina poplar (*Populus canadensis*) and white poplar (*Populus alba*) were heavily planted, remaining today as large old relict

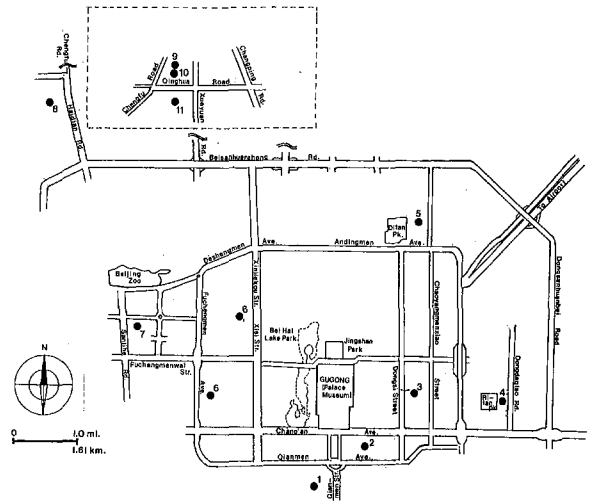


Figure 1. Sketch map of the Beijing municipality indicating locations of the neighborhoods sampled (black dots). The samples are 1)old commercial sample, 2)Zhengyilu, 3)Neiwubu Hutung, 4)Ritan, 5)Heipingli, 6) West Hutungs 7) Chegongzhuang, 8) Haidian, 9) Forestry University, newer housing, 10) Forestry University, older housing, 11) Mining College.

specimens. Today, fifty different varieties of poplars dominate the city's landscape. White poplar hybrids may comprise as much as 40 per cent and Japanese pagoda tree (*Sophora japonica*), 30 per cent of the central city's planted stock (Liu, pers. comm.). White poplar hybrids have replaced Carolina poplar which has been affected by widespread branch dieback caused by serious insect problems.

Large specimens of black locust (*Robinia pseudoacacia*), Carolina poplar and occasionally Peking willow are common in older residential areas and reflect earlier planting preferences (Fig. 2). The diversity of trees is higher in the historic hutungs (single story residential areas) than in other parts of the city, because of the abundant growing space and many individually maintained courtyard gardens. Large specimens were found more frequently in these areas as well as within older housing complexes (Fig. 3). A significant number of the Siberian elms and black locust in the hutung sample were naturalized.

Black locusts are now rarely planted, although they were very popular from 1940 until the early 1960's. The trees were often affected by the strong

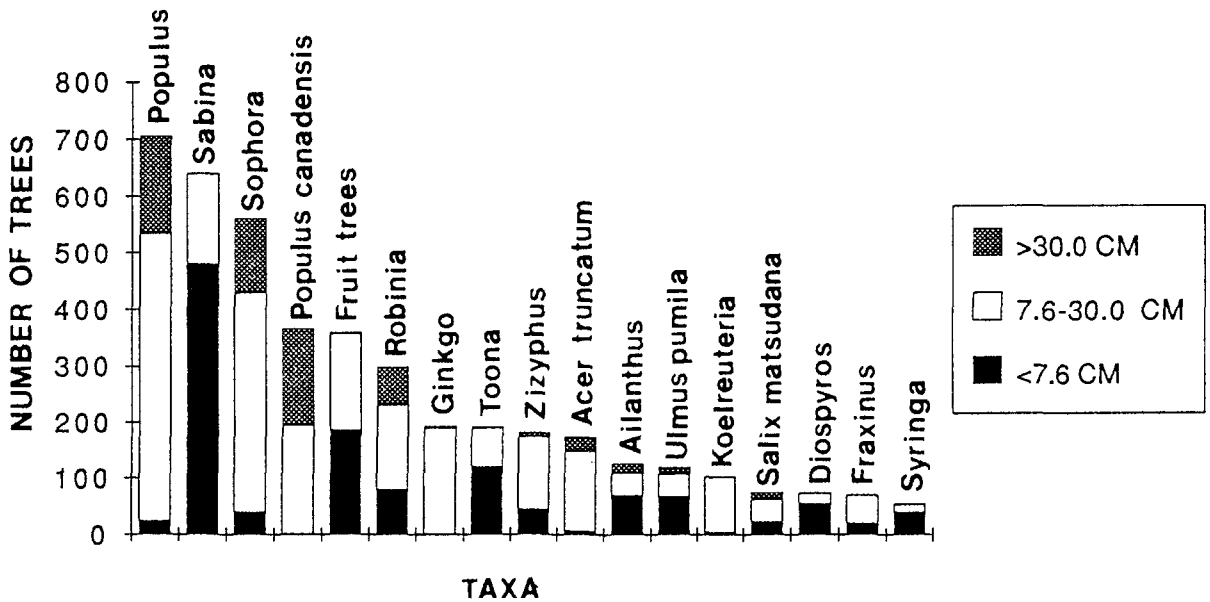


Figure 2. Summary of the major tree species encountered in a sampling of Beijing neighborhoods by size class.

easterly winds which hit the city, causing many of them to lean. Most of the locusts we observed were very old, only rarely surviving as street trees. Nevertheless, new thornless varieties are being tested and will probably be used more frequently in the near future (Liu, pers. comm.).

Shantung maple, a medium-sized tree resembling our North American maples, was also widely planted until the early 1960's. The maple adapts poorly to street conditions and suffers from insect

damage and branch dieback. The few remaining specimens along streets are declining, but trees in parks or traffic islands with ample growing space appear to be growing well.

Large Japanese pagoda trees are common in older residential neighborhoods, along Zhengyilu, and as remnant specimens in Hong Men Village (Figs. 4 and 5). Today, they are used along busy commercial thoroughfares and smaller streets



Figure 3. Courtyards in Heipingli are lined with Siberian elms and Carolina poplar planted in the 1950's.



Figure 4. Japanese pagoda trees along Zhengyilu (Justice Road), a preserved turn of the century imperial boulevard.

where space is at a premium and larger tree species are not suitable (Fig. 6.). Many trees in this genus have been planted along streets that did not have trees in the past or were widened and modernized within the past 20 to 30 years. Several species of ash are also common along such streets and boulevards, particularly velvet ash (*Fraxinus velutina*) which makes up about half of the ash trees planted. Before 1960, American ash (*Fraxinus americana*) was widely planted, but because of its tendency to suffer from lower branch dieback when maturing, it was replaced by other species (Liu pers. comm.).

Chinese juniper (*Sabina chinensis*) is now commonly planted in Beijing. Although most often

planted along small streets and hutongs adjacent to courtyards and entranceways, it is often used in conjunction with other trees and shrubs along larger streets and boulevards. Its compact form and straight stem is preferred by residents and is traditionally associated with longevity, along with Chinese pine (*Pinus tabulaeformis*) and Oriental arborvitae (*Platycladus orientalis*). With the exception of large old specimens occurring in parks, and temple and palace gardens, few are larger than 6 inches in diameter.

Fruit and Nut Trees

The Municipal Bureau of Forestry encourages the cultivation of fruit and nut trees. The hill areas surrounding the city produce large quantities of apricots, pears, persimmons, apples, chestnuts and walnuts, with crops of peaches and grapes in the lowlands. More than 40 varieties of fruit are grown in the metropolitan area. Fruit trees make up 17 per cent of the neighborhoods we sampled, particularly common jujube (*Ziziphus jujuba*), Chi-

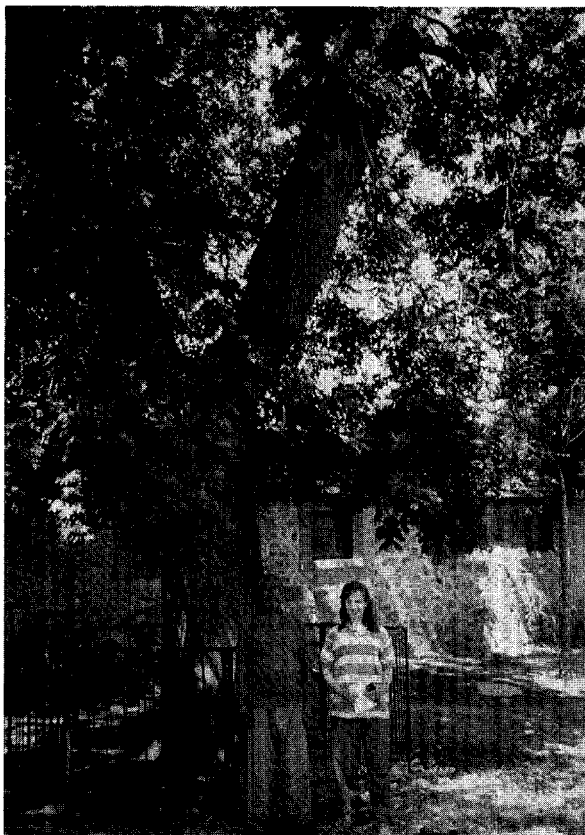


Figure 5. Large Japanese pagoda tree in the center of Hong Men Village protected by the Beijing Institute of Landscape and Gardening. The trees were spared ten years ago during the village's reconstruction. Many villages in the Beijing metropolitan area were rebuilt by the local population in the late 60's and 70's.

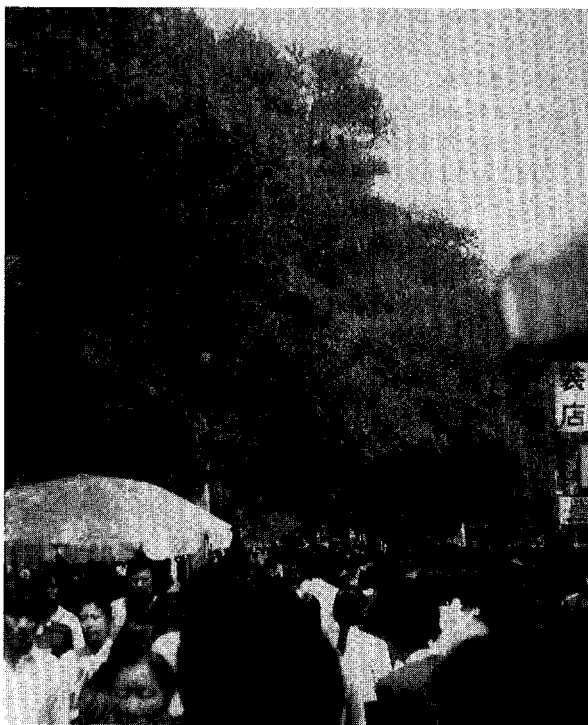


Figure 6. Wanfujing Dajie, a busy commercial street east of the Palace Museum, planted primarily to Japanese pagoda tree.

nese toon (*Toona sinensis*), and kaki persimmon (*Diospyros kaki*) (6). Pomegranate (*Punica granatum*), apricot (*Prunus armeniaca*), peach (*Prunus persica*), Persian walnut, apple (*Malus* spp.), mulberry (*Morus* spp.) and Chinese hawthorne (*Crataegus pinnatifida*) are less common, but widely distributed. Fruit trees make up over 40 per cent of all trees in the city's older single story residential housing with courtyards (Fig 7). Only walnuts are occasionally used as street trees. Most fruit trees have smaller more compact growth forms, which coupled with their food, medicinal, or herbal values, make them ideally suited to off-street urban conditions. The trees are supplied to residents upon request, when available, by the municipal government through government or farm nurseries. Most fruit trees are planted by residents, except for the occasional planting along streets and in parks.

Nursery Production

The Beijing Institute of Landscape and Gardening operates four large nurseries, totalling 1648 acres (667 ha). Also, farm nurseries in the Beijing area produce planting stock for reforestation of mountain areas and urban planting. Farmers prefer to sell to the Institute which pays proportionately higher prices for the trees used in urban landscaping. The international standard of two diameter inches is used for urban plantings, while seedlings for hillside afforestation are usually two to three years old. Street trees usually require six to eight years to reach an acceptable size.

The 380-acre (155 ha) Tongbeiwang Nursery, northwest of the city, produces over 183 species of conifers, deciduous trees and shrubs, fruit trees, grafts, vines and flowers. The species planted here reflect public preferences channelled through requests made by the city's district planting offices. In 1989, black locust, Chinese juniper, weeping willow, peach, plums and ornamental cherries, common jujube, and Japanese pagoda tree were the most frequently planted trees. Among the top trees planted by the nursery are apricot, peach, common jujube, apple, and Chinese toon, very commonly planted by residents in courtyards and home gardens.

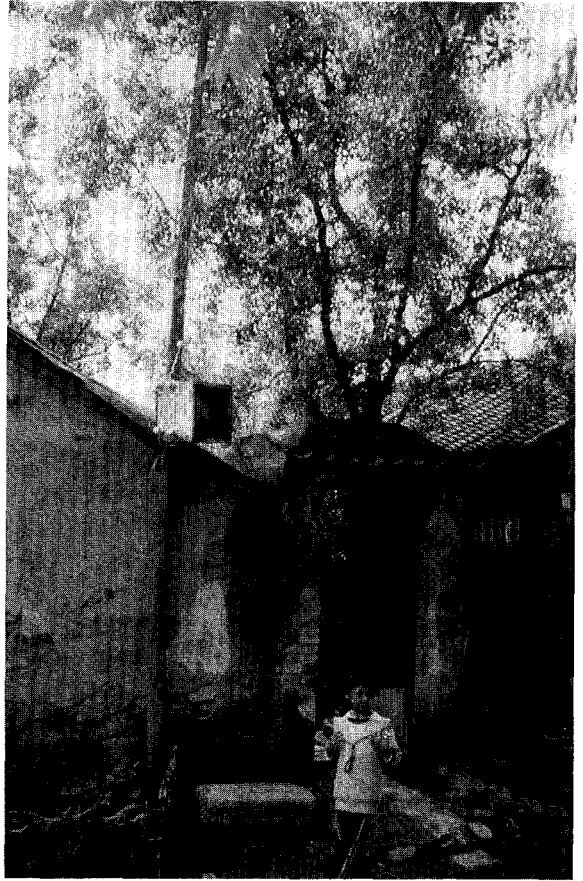


Figure 7. Courtyard garden with Chinese dates in the Haidian District. Most fruit trees are planted within courtyards or adjacent to residential homes.

Management Practices

In some areas, test streets have been planted to determine which trees are suitable to Beijing's conditions (panicked goldenrain tree and Persian walnut were observed by the author). Along one commercial street, tree-of-heaven was interplanted with Japanese pagoda tree. The Japanese pagoda tree forms an understory beneath the rapidly growing tree-of-heaven which is removed before it gets too large. The tree-of-heaven is rarely planted today; most specimens we observed were in the older hutung areas and appeared to be naturalized.

While the canopies of widely spaced street trees provide important visual effects in western countries, Chinese trees are closely spaced and the stems are used for maximum visual effect. The

origins of the Chinese design can be traced back to regulations enacted by Kublia Khan in the 13th century requiring trees to be planted only two paces apart along both sides of all public roads for shade as well as road markers during snowy winters (3).

Street trees are usually planted 10 to 15 feet apart, encouraged by a government mandate to rapidly increase greenspace in the city. Close planting of trees encourages moisture retention, shading of roots, and some additional protection of the bole and canopy from extreme temperatures and winds. In addition to providing a higher canopy cover over the city, it provides wood for a variety of uses during subsequent thinnings.

Grassy areas are much less frequent in Beijing than in western cities because of the long winter dry season and the emphasis placed on the planting of trees and shrubs, considered more important in influencing air quality, climate, and wind. Once established, the dense canopy of wooded areas inhibits good grass cover. Adding to this, automobiles and bicycles park almost everywhere, making it difficult to maintain grass.

All large roads and boulevards are planted with at least two tree species, often in two or more rows (Fig. 8). Tree planting pits are approximately 6 feet by 6 feet (2m x 2m) when space is not limiting and planting strips are not possible. Newly planted trees are usually watered in late March, early April and again in late fall (Liu, pers. comm.).

Wider planting strips are often used along large boulevards. Thirty -meter-wide forest bands have been planted along major thoroughfares throughout the city as well as along roads leading out of the city. In suburban areas, there are concentric, though unconnected, bands of forests, while in the outer counties more than 10,000 hectares of "protection" forests have been planted to reduce wind and dust in the city (Yu, pers. comm.). In 1949, the forest cover of the metropolitan area was 3.2 per cent, comprised mainly of 740,000 acres (300,000 ha) in large forested blocks. Today, greenspace cover throughout the metropolitan area averages 26.9 per cent (Liu, pers. comm.).

Every city in China has its official 'brother' trees and 'sister' flowers, often chosen following the advice of local park and horticulture departments. The trees are often heavily planted, becoming

symbols of the city and strongly influencing its character. The Japanese pagoda tree and Oriental arborvitae are Beijing's official city trees.

Park, Temple, and Palace Greenspace

All parks in the Beijing urban area are fenced, restricted to pedestrians who pay an admission fee. Most parks receive heavy use, resulting in widespread soil compaction and destruction of understory vegetation, despite intensive maintenance. At the Temple of Heaven (which originates from 1400-1550 A.D.), many of the large trees require soil aeration and fertilization to stem their decline. Six miles northwest of the city in the Summer Palace park, large areas of rock hard soils and heavily compacted paths surround the large old Chinese junipers, Oriental arborvitae and Chinese pines in the formal gardens as well as the younger trees in its wooded hills and glades. Species diversity is low in many areas of the park and it appears that most of the trees along the heavily travelled walkways would not survive if planted today.

Fifty years ago, large trees survived only in and around Buddhist and Taoist temples. Most other trees were destroyed by the invading Japanese armies. Large, old, and historic trees and wood-



Figure 8. Dongangiao Street in the Ritan District. A typical planting pattern along a large boulevard (from left to right: Japanese pagoda trees, Chinese juniper, and crape myrtle (*Lagerstroemia indica*), white poplar, black locust, forsythia and peach (*Prunus* spp.). Two-lane side road is for bicycles.

lands are still concentrated in palace and temple gardens, monasteries, and parks where they have been protected by religious and cultural traditions (Fig. 9).

During the Cultural Revolution (approximately 1965-1975), many old, historically significant trees were destroyed or damaged. Today, the trees are being replanted and their historical and cultural importance is again being acknowledged. The Chinese government now realizes that religion, tradition, and culture can be used to promote positive conservation values. Many deteriorated historic buildings are being renovated and steps are being taken to protect nearby old trees and forested watersheds.

Legislation and Programs to Protect Urban Trees

The development and expansion of Beijing has been rapid and the government recognizes that the retention and planting of vegetation cannot keep pace. The government reflects the general public's concern and appreciation for trees. Informal regulations have long prohibited the removal or cutting of any tree that has grown "taller than a building," or is more than 100 years old, without approval from the Beijing Forestry Bureau and notification of the Beijing Institute of Landscape and Gardening. Although most bureau regula-



Figure 9. *Ginkgo biloba* from the Liao Dynasty (947-1125 A.D.), believed to be 1000 years old. Emperor Qianlong of the Qing Dynasty (1644-1911) bestowed this Ginkgo at the Tan Zhe Si Temple with the title "King of Trees".

tions begin unofficially, they must be approved beforehand by the People's Congress and are eventually followed by formal laws and regulations. Beijing's first official urban forest regulations were enacted in June, 1990. The Beijing Institute of Landscape and Gardening has jurisdiction where fewer than 10 trees in one location are to be removed. If more than 10 trees will be removed, permission must also be granted by the City Government's Municipal Gardening and Landscape Administration.

All property in cities is publically-owned so there is no distinction between public and private greenspace. The lack of private land ownership appears to have little effect on compliance with regulations and the generally high level of care given to trees by residents, who appreciate and treat them as their own. Nevertheless, a few cases potentially in violation of the law were observed, usually associated with storage sheds or unsanctioned yard construction near large trees.

A tree must be diseased or damaged for permission for removal to be granted. If permission is granted, a resident may remove the tree or pay the Institute of Landscape and Gardening to do so. All wood must be returned to the Institute. The penalty for cutting a 6-inch diameter tree without permission is 300 to 500 yuan (the average monthly base salary is 150 yuan [33 \$US]).

Each city district has a planting bureau in charge of tree maintenance. The bureaus also must obtain permission from the city's central planting office to remove, cut or prune trees based on the advice of the Beijing Institute of Landscape and Gardening. Small streets and lanes are managed by the district planting bureaus while the City Parks Bureau is responsible for larger streets and parks, again with the input of the Institute of Landscape and Gardening. The tree species planted are chosen by the City Planting Office in consultation with district bureaus and the Institute.

The Beijing metropolitan area has over 40,000 trees more than 100 years old. Most old trees in Beijing's central urbanized area are within temple and palace parks (22,000) while the rest are found in the suburbs; 2,000 of these trees are found on the Temple of Heaven grounds. The Beijing Institute of Landscape and Gardening has compiled

an inventory of large and historic trees including information on species, size and sometimes age, location and maintenance history. The trees have been tagged by the Institute and cannot be removed unless they pose danger to the public. When an old tree must be removed, it is replaced by another of the same species, if possible at the same location (Liu, pers. comm.). Efforts are made to avoid destruction of large trees during construction, encouraged in some cases by public opposition to removals.

Every government employee in Beijing must plant and maintain two trees per year in the mountains. Able-bodied employees spend two weeks each year maintaining, pruning, and planting trees. The government is also endeavoring to rekindle and modify traditional tree planting customs. Land has been set aside to encourage the planting of trees to commemorate marriages, births, and deaths. The program, which has been in effect about a year, will probably be successful, since it encourages traditional customs which people are inclined to follow (Yang, pers. comm.).

Middle schools (Grades 7-9) are given small plots of land to divide among their classes to plant and maintain. The Central Committee in 1979 designated March 12 of each year National Tree Planting Day. Since then, volunteers have planted 500 million trees in the Beijing metropolitan area, particularly in the suburbs and nearby mountains (1). Unfortunately, survival rates have often been low, plagued by the problems of managing such a vast planting.

Tree planting around factories has been mandated by the government since the 1970's and is considered very important in controlling industrial air pollution. Trees are also planted for screening and wind reduction, but it is unlikely that these plantings alone will result in any significant improvement in air quality. Relocation of industrial development to the south and east will be more important in reducing the air pollution entering the city on northwesterly winds.

Research

The Commission for Integrated Survey of Natural Resources (CISNAR) hosted our visit. The Commission has recently expanded its research to

include natural resources in the industrialized areas of eastern China, and is interested in increasing research cooperation in urban ecology. The Beijing Institute of Landscape and Gardening is another good starting point for anyone wishing to study trees in Beijing. The Institute studies the structure and condition of Beijing's greenspace to assist the city government in forest management, urban and greenspace planning, and enacting legislation. The greenspace cover of Beijing has been mapped and categorized into nursery, lawn, conifer, broadleaf, mixed forest, open forest, street tree, solitary tree and farmland for urban planning purposes. The urban heat island has also been mapped in an attempt to describe the relationship between vegetation cover and temperature. Researchers believe that for every 10 percent increase in greenspace cover, the temperature may decrease 1°C. Since the heat island intensity of Beijing has been calculated to 4 to 5°C, it is postulated that it may be possible to control the heat island by increasing the greenspace cover to 50 percent. Researchers also believe that increasing greenspace cover by this amount will substantially improve air quality by reducing sulfur dioxide, suspended particulates and benzopyrene. As a result of these studies, which received a state award, the Beijing Government has decided to increase greenspace cover to reduce wind and atmospheric pollution, and dissipate the urban heat island.

Concluding Discussion

The present distribution and composition of the Beijing urban forest can be explained by understanding 1) the cultural and traditional species preferences indicated by the large old trees of parks, temples and palaces, and garden fruit trees; 2) planting practices and choices since the 1940's, with particular emphasis on recent large plantings and management practices; and 3) the effects of land use and age of housing stock, particularly as it influences available growing space. In these respects, Beijing is similar to many cities throughout the world.

China has until recently taken a low technological, and of necessity, labor intensive approach to solve her environmental problems. Tree planting lends itself to this scenario. The Beijing Govern-

ment has made a concentrated effort to use all available growing space to plant trees to improve the quality of life. Since the central city has very little additional growing space, areas have been allocated around the city for forest parks, the density of plantings in the city has been increased, and the revegetation of all available growing spaces in the city has been accelerated. The effort has strong support from the central government, but more significantly, is routinely implemented by building departments and other government agencies. Nevertheless, it will be very difficult, perhaps impossible, to increase greenspace cover to 50 per cent in such a rapidly growing city. Also, the ability ascribed to vegetation in removing air pollutants may be overly optimistic. More costly measures of pollution control will also be needed.

The Chinese people have a special mindset in dealing with nature, caused by their divergent history, religion, and culture. They are strikingly knowledgeable about and take an active interest in the trees and landscapes of their neighborhoods, and are a great asset to managers of the urban forest.

Although the cultures of China and the United States are very different, we have many geographic similarities and environmental problems in common. The climate and environment of Beijing is similar to some parts of the United States, and trees used in urban plantings have been exchanged by both our countries. Dawn redwood (*Metasequoia glyptostroboides*), Maidenhair tree (*Ginkgo biloba*), Zelkova, Chinese tree-of-heaven, and Princess Tree (*Paulownia* spp.) are all native Chinese genera planted or naturalized in parts of the United States. Since the United States and China have many geographic similarities and common problems, new exchange programs will contribute to our understanding of urban forests.

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Resumé. Les pratiques de gestion, la production en pépinière, les préférences du public, le développement historique et l'utilisation du territoire influencent tous la composition en espèces, le diamètre et la distribution forestière à Beijing (Pékin) en Chine. L'inventaire des arbres comprend, pour presque 55%, quatre genres (*Populus*, *Sabina*, *Sophora* et *Robinia*). Depuis 1949, la couverture verte de Beijing s'est accrue dramatiquement en raison d'un engagement significatif du gouvernement municipal. Les vieux arbres survivants d'époques de plantations récentes sont retrouvés hors rues, essentiellement dans les vieux secteurs résidentiels et institutionnels. La recherche se concentre sur l'utilisation des arbres pour un contrôle économe de la température, du vent et de la pollution tout autant que sur des motifs esthétiques. Une législation pour protéger les arbres vieux et historiques était mise en vigueur en 1990 pour suppléer aux règlements informels administrés par le Bureau de la Foresterie et l'Institut du Paysage et du Jardinage. Le soutien public pour la préservation et la plantation d'arbres est solidement enraciné dans la culture et la tradition chinoises.

Zusammenfassung. Management-Praktiken, Baum-schulproduktion, öffentliche Meinung, die historische Entwicklung und die Landnutzung beeinflussen die Artenzusammensetzung und Waldverteilung in Beijing, China. Vier Gattungen (*Populus*, *Sabina*, *Sophora* und *Robinia*) stellen 55% des Baumbestands. Seit 1949 haben die Grünflächen in Beijing dramatisch zugenommen mit einer deutlichen Beteiligung durch die städtische Regierung. Bäume aus früheren Jahren stehen außerhalb des Straßenbereichs, vor allem in älteren Wohnvierteln und in der Umgebung von Institutionen. Gesetze zum Schutz alter und historischer Stadtbäume wurden 1990 verabschiedet zur Ergänzung der Regeln des Amts für Forstwirtschaft und des Instituts für Garten- und Landschaftsbau. Die öffentliche Unterstützung für Baumschutz und Baumpflanzung ist stark in der chinesischen Kultur und Tradition verwurzelt.