



Currently, more than half of the world's population lives in an urban environment. Urbanization has been both a gradual and cyclical process since the beginning of human civilization. However the rate of urbanization increased dramatically during the industrial revolution and evolved into "overflowing settlements" in the second part of the Twentieth Century. During this time, a post-World War II population boom in developing countries was largely absorbed by the cities. As a result, 80 percent of the European populace now lives in the urban areas.

Arboriculture and urban forestry have important roles in the management of urbanization and establishment of habitable cities. All the greenspaces, from flowerbeds to periurban (outlying) forests offer a "concept of nature," and fulfill a paramount role in improving quality of life. Greenspaces help cities reach the minimal thresholds for human well-being.

Many view greenspaces simply as an outlet for recreation. However, they offer many other benefits that improve a citizen's quality of life. These benefits have been the subject of numerous research projects, including a European COST study, the ASEM Symposium (Asian European Meeting), and the 5th Chinese Urban Forestry Conference.

Developing countries will play an increasingly important role in global environmental issues as their major cities are growing much faster and often in a less sustainable way than those in the most developed countries. This article summarizes future arboricultural challenges identified at conferences held all over the world in the last two years. It focuses specifically on climate change, trees and infrastructures, emerging diseases, and tree stability. Though not mentioned, socio-economic and juridical aspects of urban forestry, site restoration, and pollution mitigation are also important and should be considered when planning and managing green areas.

CLIMATE CHANGE AND ARBORICULTURE

In order to assess the impact of climate change on arboriculture, reliable predictions of regional and global climate change trends are required. Many concede that world temperatures may warm at an unprecedented rate compared to historical trends. The main cause of this warming is believed to be the "greenhouse effect."

To address this development, the Climate Change and Urban Forestry Congress (www.tree4climate.org) held in Rome in 2007 addressed the need to select plants tolerant of climate change. In

some areas, the frequency of extreme weather events (e.g., heavy storms, tornadoes, and other large natural events) may increase. However, in other areas (such as the Mediterranean), drought-tolerant plants may be needed to cope with an increase in prolonged summer droughts. Drought may have a significant impact on the survival and growth of newly planted trees and may lead to reduced disease and pest resistance. In order to grow sustainable, healthy urban forests, trees will need to be matched to these tougher growing conditions managed to reduce water stress. This may require urban foresters to think ahead and select both native and non-native species or species provenances adapted to predicted conditions.

Other factors, important in themselves and as influence by climate change, must be considered when selecting plants. These factors may be divided into three major categories: design, site, and maintenance considerations. Factors specific to selecting trees for city streets or park landscapes include pruning requirements, tree stability, disease resistance, catastrophic insect pests, soil adaptation, complementary planting, shade or sun adaptation, provenance, and adaptiveness of cultivars.

Finally, plants and management practices should be selected to maximize net atmospheric carbon dioxide sequestration

(Nowak et al. 2002). In areas experiencing more frequent drought conditions, it may be advantageous to select trees that are both efficient in sequestering carbon dioxide (CO₂) and have a higher rate of net photosynthesis while minimizing water lost through transpiration (high water use efficiency or WUE).

ARBORICULTURE: AN INTERNATIONAL PERSPECTIVE ON THE EFFECTS OF URBANIZATION AND CLIMATE CHANGE

By Francesco Ferrini and Giovanni Nicolotti



The city of Shenzhen (China), founded in 1979, is now close to 10 million citizens.

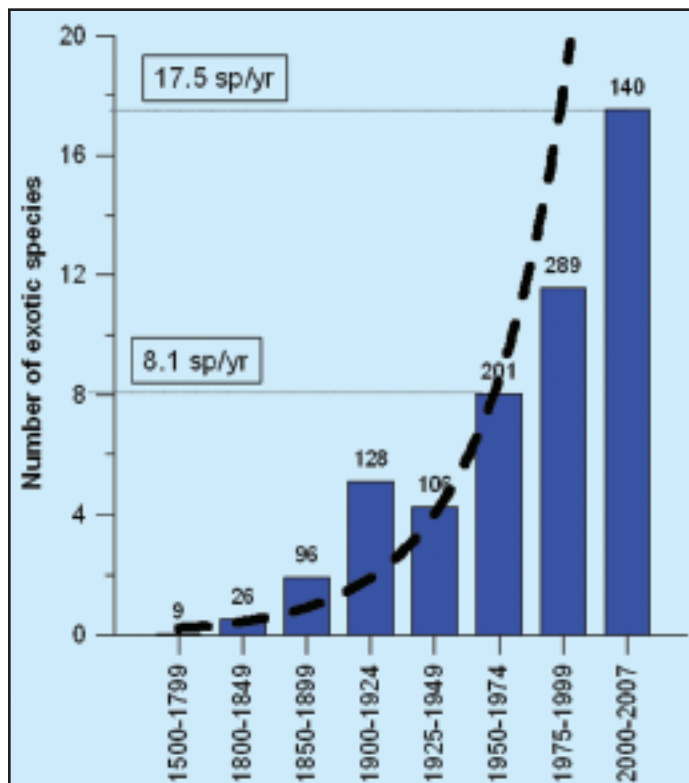
CLIMATE CHANGE AND URBAN FOREST PATHOSYSTEMS

Both the introduction of new pests and diseases and the spread of indigenous parasites may affect ecosystems. Exotic pathogens and pests may be extremely virulent as they have not co-evolved with local hosts. Interactions between plants and pests are further influenced by changes in climatic conditions. New pathosystems will develop in response to climate ►

Arboriculture: An International Perspective on the Effects of Urbanization and Climate Change (continued)

change and global trade. These new conditions will limit or exclude the use of some ornamental tree species and require greater selection considerations.

Globalization is increasing and with it the worldwide commercial trade of plant materials, seeds, seedlings, and trees. Additionally, tourist travel may result in the transfer of plant materials as souvenirs, bringing pests and diseases with them. Transfer of plant materials by travelers is difficult to regulate as souvenirs may not go through inspection at customs. Both commercial trade and tourism have led to an average of 17 new parasites introduced into Europe each year. This is an exponential increase over recent centuries. To limit these introductions, updated information about the greatest potential risks must be available and effective identification methods must be developed (Stenlid et al. 2007).



Number of exotic parasites introduced into Europe over the last centuries (from Alain Roques - modified).

DISEASE INFESTATION

Climate change and pest introduction may lead to future catastrophic insect and disease infestations. Notable past epidemics include Chestnut blight (which removed the American chestnut as a dominant forest species in North America) and Dutch Elm Disease (which devastated urban forests in Europe and North America).

To prevent future catastrophe, the following strategies must be put in place:

- Improve customs inspections process (key concern)
- Educate tourists, commercial operators, and nurserymen on the importance of sanitation and sterilization practices and disease/pest control
- Establish a monitoring network to guarantee well-timed and correct detections
- Update quarantine lists regularly
- Eradicate detected threats quickly while at manageable populations
- Establishment of management plans and species replacement strategies to cope with new threats if eradication prove to not be feasible

Climate change can also increase fungus pathogenicity, alter host susceptibility, and extend parasite ranges. In the past, most parasites coming into Europe had temperate origins. Relatively few parasites (6.7 percent) introduced into Europe came from the tropical and sub-tropical regions. During the last twenty years, global warming has helped increase the number of imported tropical species by 37 percent.

Induced climatic stress can also increase the susceptibility of resistant hosts. Ornamental trees growing in urban environments normally suffer the chronic weakness due to severe constraints, such as air and soil pollution, low soil fertility, pruning and other wounds, and underground disturbances.

TREES AND INFRASTRUCTURE

As urbanization increases, the significance of infrastructure and vegetation conflicts increase. This has been a major consideration in Europe and is addressed in the COST Action C15 initiative, "Improving relations between technical infrastructure and vegetation."

Tree roots can contribute to severe damage to sewer or septic lines, storm water drains, water supply lines, building foundations, sidewalks, streets, parking lots, curbs, walls, and swimming pools. Many species, such as the Italian stone pine (*Pinus pinea* L.) and the sycamore maple (*Acer pseudoplatanus* L.) are known to interfere with pavement and sidewalks. D'Amato et al. (2002) found that the probability of finding root growth underneath a sidewalk was influenced by genera. *Gleditsia* developed the highest number of roots growing beneath the sidewalk, at the smallest trunk diameter, followed by *Zelkova* and *Koerleuteria*. *Quercus* produced the lowest number of roots.

Although tree roots are blamed for cracking concrete and invading sewer lines, it could also be argued that these structures failed because they have not been properly engineered to function in a landscape that contains growing trees and their roots. Unfortunately, the main approach in too many cities has been to remove trees rather than to find ways to redesign structures to be compatible with trees.

Impervious surfaces and small planting pits restrict soil water and oxygen (Kopinga 1989; Kjelgren and Clark 1993). Under natural conditions, roots extend beyond the dripline of the crown. Planting pits must be designed using appropriate materials and with sufficient space to allow for healthy tree growth and physical stability of the tree.

Unfortunately, current practices in European urban areas often fall significantly short of these guidelines. The size of planting pits often vary between 2 m³ and 10 m³ per tree (2.76-13.79 cubic yards). Even tree pits as small as 0.5 m x 0.5 m (20 ft x 20 ft) have been reported as a standard design scheme (Pauleit 2003).

Numerous researchers have suggested the use of root barriers to reduce between green and gray infrastructure (Hamilton 1984; Coder 1998; Randrup et al. 2001). However, the use of these barriers is not universally accepted (Mead 1994). Root barriers are a physical or chemical impediment intended to limit root growth to designated areas away from infrastructure (Morgenroth 2008). There are three main classes of root barrier: traps, inhibitors, and deflectors (Coder 1998).

Traps are woven or perforated materials that allow root tips to penetrate small holes, but girdle roots as they increase in diameter.



As urbanization increases, the significance of infrastructure and vegetation conflicts increase, as with this willow oak (*Quercus phellos* L.).



Tree roots have the potential to cause damage to sewer or septic lines, stormwater drains, building foundations, sidewalks, parking lots, swimming pools, and other infrastructure.

Root inhibitors control root growth through chemical intervention. Root deflectors are physical barriers which re-direct roots away from structures (Morgenroth, 2008).

The success of root control methods may be influenced by species and site conditions. While barriers may reduce infrastructure conflicts, their use is not without consequence. Severe restriction of large root development in one or more directions may predispose trees to instability (Morgenroth 2008). Also, some European countries may ban the use of herbicide root inhibitors in urban areas. Barriers may also impact the flow of air and water in soil.

GLOBAL CHANGES AFFECT TREE BIOMECHANICS AND STABILITY

Many of the factors mentioned earlier can decrease tree stability and lead to a higher propensity of failure. Tree assessment is largely based on the cultural background of the technician, who assesses the tree based on knowledge and experience gained in a certain environment. Trees can reflect an abrupt change in climate conditions in various ways. This may lead to a misvaluation of the phenomenon, as signs and symptoms not common to the region or species may be present (Ferrini et al. 2008).

Assessments that factor in local environmental and weather conditions may also be affected. For example, an assessment might be made in reference to a peak, average wind speed in an area, using a value of 24 m/s (54 mph). If the reference wind speed increases from 24 to 29 m/s (65 mph) over 50 years, the stress a tree must endure will increase dramatically (+46 percent) as load is proportional to the square of wind speed (Ferrini et al. 2008).

In this example, an arborist must account for changes in average wind speeds by selecting species adapted to these conditions, evaluating existing trees, and incorporating management techniques such as pruning to reduce the effects of increased wind pressure as needed (Gilman et al. 2008a; Gilman et al. 2008b).

Finally, a failure database that takes into account the weather conditions at the time of tree failure must be established. This information may then be integrated in an appropriate environmental analysis of peak wind events and their effects on tree biomechanics.





Arboriculture: An International Perspective on the Effects of Urbanization and Climate Change (continued)

This will be a significant improvement of current technical analyses as adjustment may be made for short- and long-term changes in environmental conditions.

CONCLUSIONS AND RECOMMENDATIONS

Nilsson and Konijnendijk (pers. comm.) brilliantly summarized the most important topic to emerge from the ASEM Conference held in Guangzhou, China, stating the challenges caused by urbanization are numerous and diverse. While urban populations are increasing, urban areas are expanding even more rapidly. This leads to strains on urban management, infrastructure, as well as on quality of life and environment (Konijnendijk 2008).

Urban areas are among those that will be most affected by climate change, as demonstrated by the urban heat island effect. The mitigating effect of urban forests on local and global climate change are finally being realized, but there is still need for more research and recognition. Moreover, more attention should be given to creating a diverse urban forest that is better adapted to climate change.

Sustainable arboriculture entails maximizing the benefits of urban trees through the use of safe and environmentally sound management practices. Sustainable arboriculture must be economically viable, socially just, and accessible to all citizens. Although the importance of urban green areas has been acknowledged globally to be of utmost importance, the term “sustainable arboriculture” is often used loosely and in a general manner as a label, brand or icon to make it acceptable to all types of stakeholders and under various environments.



People of all ages doing physical exercise in an urban park in Guangzhou (China).

In the coming decades, arboriculture and urban forestry will have to face many challenges as populations increase and demographics change, natural resources are strained, environmental degradation persists, climate continues to change, and globalization increases. At the international level, urban green areas are increasingly being perceived as vital spaces for the development of important ecological, social and economic functions. Therefore, there is a strong need for research in all of the areas addressed in this article if the benefits brought by trees are to be maximized.

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