ECOLOGICAL BASES FOR SELECTING URBAN TREES

by George H. Ware

Abstract. Survivability of urban trees is closely related to their "toughness" or inherent capacity to endure stress. Stress-tolerance can usually be gauged by assessing ecological adversities of the natural environment of trees as components of ecosystems. Survival and contributions of urban trees depend upon three major considerations: selection of appropriate trees, choice and preparation of favorable planting places; and handling (e.g. proper transplanting) and follow-up care.

Selection of trees for urban planting sometimes neglects considerations related to survivability. Attractive trees may be selected from lists of tough, durable, and ecologically appropriate trees, but aesthetic appeal alone provides insufficient basis for selecting trees with good survivability.

Communication concerning selection of an appropriate urban tree most conveniently begins at the species level, the taxon for which taxonomic, physiological and ecological attributes are described in general reference sources. Because woody-plant species often have geographic ranges extending over climatically diverse regions, the species level may be too general for communicating information about promising prospective trees for urban use. Santamour (8) uses the example of red maple (*Acer rubrum*), which occurs in natural populations from Minnesota to South Carolina (and southward). He notes that red maple trees originating from natural populations in either state do not grow well in the other state. In Santamour's example, the important concept of provenance (geographic place of origin from naturally occurring populations) is especially emphasized. Information on provenance is often best communicated by dealing with subspecies, varieties, ecotypes, cultivars, and clones, all of which have more closely identifiable merits and limitations than does the species category. Santamour's example deals with native red maples from regions with great contrasts in both summer and winter temperatures. Contrasts of high and low rainfall in different parts of a species' natural range may also mean differences in the genetic and ecological character of widely separated tree populations.

Local, natural tree populations are generally recognized as good sources of trees for urban use locally. But commercial distribution often sends trees far from their place of natural origin. For example, plants from natural populations in Tennessee are most at home in Tennessee or places with climates similar to Tennessee. Native plants from Tennessee are likely to make poor adjustments when planted in northern Illinois, albeit some manage to survive. The occasionally encountered belief that somehow eventual adjustment will be made is not borne out by the evidence. Transplanting nursery stock of plants native to Tennessee and adjacent states to northern areas may lead to problems. During the severe winter of 1979, Washington hawthorn (*Crataegus phaenopyrum*) was winter-damaged in northern Illinois. Recovery required several years. The native range of Washington hawthorn is several hundred miles south of Chicago.

Limitations associated with insufficient climatic hardiness of plants native to the USA are better understood than are the limitations associated with taking native plants from regions with maritime climates to regions with continental climates. The climates of much of western Europe and Japan are not sufficiently similar to those of American midwestern states for European and Japanese plants to perform consistently well in the central part of the USA. Japanese and European plants are grown much more successfully in Atlantic coastal states with their ocean-tempered climates. However, parts of China and Russia have continental climates quite similar to those of midwestern states. These climatic analogues in other parts of the world provide good possibilities as regions for seeking, selecting, and testing plants for landscape use in midwestern states. In addition to marked temperature extremes in regions with continental climates, there is the fluctuation factor — abrupt changes in temperatures, with early autumn freezes and late spring freezes causing plant damage. Widely planted Siberian elm (*Ulmus pumila*) has a huge geographic range in China and Russia. Yet the "Halloween freeze" in 1991 killed many thousands of Siberian elms in the Great Plains when sub-zero temperatures caught trees insufficiently dormant (3). Such a devastating episode may also be viewed as an opportunity for identifying surviving trees that may be better attuned to the rigors and vagaries of the climate of the Great Plains.

Tough Trees for Tough Situations

Locally indigenous trees generally fare well locally in urban parks, campuses, and other open areas. But what about the restricted or inhospitable planting places along streets, especially in downtown areas? These microenvironments are markedly different from the general climatic and soil conditions influencing the growth of local woodlands. The phrase "tough trees for tough situations" suggests that for adverse urban environments, trees from nature's tough-tree testing laboratories may offer the best possibilities.

Floodplains and swamps are tough-tree testing places (Fig. 1). Prolonged flooding in springtime and excessively dry soils in summer permit survival of only those trees evolutionarily adapted to a broad spectrum of soil-moisture conditions. Trees that can the tolerate low oxygen levels of soils of swamps and floodplains can also tolerate the low oxygen levels of clayey soil, compacted soil, or rubble-laden fill material that often comprise what is encountered as urban soil. The most commonly planted street trees of many towns of midwestern states are floodplain trees: silver maple (*Acer saccharinum*) and green ash (*Fraxinus pennsylvanica*). A third floodplain species, American elm (*Ulmus americana*), was once the most commonly planted street tree in much of the eastern and midwestern USA. Swamp white oak (*Quercus bicolor*), river birch (*Betula nigra*), and Drummond red maple (*A. rubrum var. drummondii*) are additional examples.

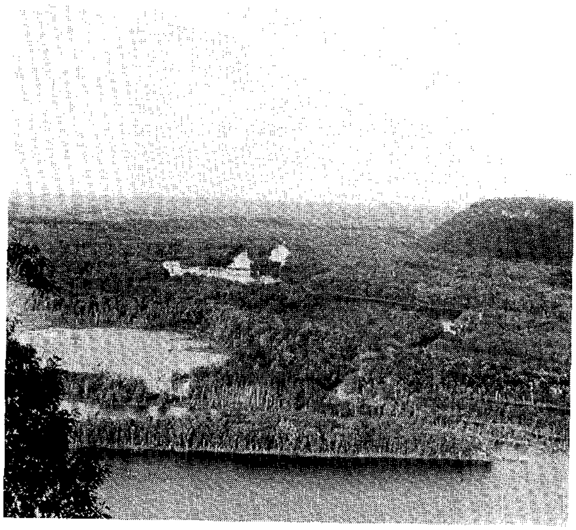

Figure 1. The floodplain at the confluence of the *Misssissippi and Wisconsin Rivers* contains several tree species that are widely used as urban trees.

Savannas are also tough-tree testing places. These plant communities usually have low rainfall levels and contain only a few kinds of trees. Some examples are: bur oak (*Quercus macrocarpa*), hackberry (*Celtis occidentalis*), honeylocust (*Gleditsia triacanthos*) (Fig. 2), and Kentucky coffeetree (*Gymnocladus dioica*). Even in humid forested regions there are scattered areas where soil formed on limestone or chalk underlies savanna-like groupings of *Crataegus, Viburnum, Cornus, Juniperus,* and *Quercus*. Trees of species naturally at home on shallow clay soil developed on limestone, may cope well with difficult substrata of urban planting places.

Insufficient rainfall may limit the distribution of a trees with a large geographic range. These border trees have been stress-tested and selected by nature for millennia and provide sources of genetic material from which tough trees may be selected. Some examples of forest trees that have range edges west of the Mississippi River are: American linden (*Tilia americana*), sugar maple (*Acer saccharum*), black maple (*A. nigrum*), red maple (*A. rubrum*), red oak (*Quercus rubra*), white ash (*Fraxinus americana*), and ironwood (*Ostrya virginiana*) (1). A tree from a dry and droughty

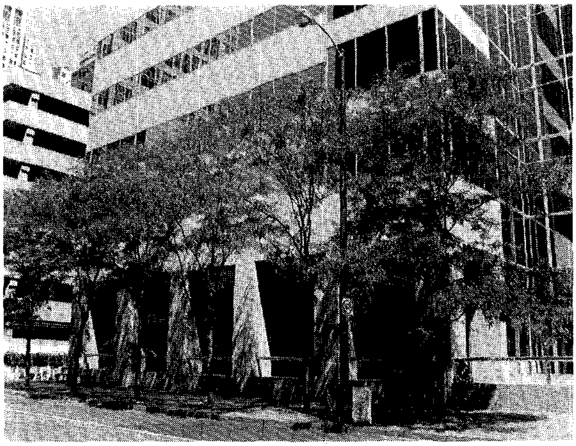

Figure 2. Honeylocust is used extensively in downtown Chicago.

border section of its geographic range appears to have better coping capacity for urban sites than does a tree from a more climatically favorable part of the range.

Trees from drier parts of their range have higher genetic root-crown ratios than trees from more climatically favorable parts of the range. The more extensive root system provides extra resilience and margin for recovery following episodes of adversity, especially drought. On the other hand, generous allocation of photosynthetic products to the root system may mean slower top growth, which is especially evident in the slow growth rate of saplings. There is a lesson: greater survivability may come at the expense of reduced top growth. But rapid top growth is usually a priority in nursery production. Black maple from Iowa is an excellent example of a tree that exhibits slow top growth in early years even though the total biomass of a sapling may approximate that of a sugar maple sapling from an eastern state, the same age but with more above-ground growth (9).

Another approach to choosing successful urban trees for adverse environments is to seek out **pioneer species**, i.e., those plants that colonize open fields or newly formed land surfaces such as barren areas left behind following coal or gravel removal. Pioneer plants have the capacity to endure a great deal of environmental adversity, both above and below ground (2). By their success in nature's laboratories, these plants demonstrate their capacity to cope in man-made adverse situations. In the midwestern states some examples are species of *Rhus, Crataegus, Ulmus,* and *Cornus.* Pioneer trees on sandbars of rivers are willows (*Salix*) and poplars (*Populus*).

Urban Tree Problems Begin Underground

It has been stated that more than 80 percent of urban tree problems begin in the soil (7). This is the basis for giving close attention to the capacity of root systems to perform satisfactorily in difficult substrata. The most common problems for trees planted in restricted places are attributable to poor drainage and root drowning, summer dehydration of roots, roots outgrowing the soil volume available to them, increasing water and nutrient needs, and alkalinization or salinization of the soil (11). Periodic selective pruning of the crown may extend the life of the tree, but detrimental soil changes such as rising pH levels or increasing soil salinity may not be easily modified. Judicious reduction of the crown has been likened to the grooming of a large bonsai plant. The bonsai analogy breaks down with the virtual impossibility of renewing inhospitable soil. Evenness of soil moisture is an important consideration. Root damage may come from prolonged conditions of excessive soil moisture or prolonged soil dehydration. The damaging episode may be half-forgotten when crown die-back appears.

Suggested Trees for Limited Spaces

The main goal in selecting trees for limited spaces is to produce a long-term harmonious relationship between the tree and its environment, both above and below ground. As previously described, limited planting space requires that selection criteria give much weight to the physiological and ecological credentials (coping capacities) of prospective tree selections. However, the constraints of limited planting spaces also require that ultimate potential size of trees must receive attention. The more rapidly a tree exploits all of its limited root space, the greater the precariousness of its environmental equilibrium because of the likelihood of episodes of excessive soil-moisture depletion. Small trees, slowly growing trees, easily trimmed trees, and perhaps fastigiate or columnar trees, are possibilities that are tolerant of both above-ground and below-ground constraints.

Here are some possibilities of trees for restricted spaces (Fig. 2). Amur maple (*Acer ginnala*), Tartarian maple (*A. tataricum*), and hedge maple (*A. campestre*) may be useful as small to medium-sized trees. All three require shaping and grooming but are quite useful for restricted spaces. Cutleaf cultivars of silver maple usually grow slowly in limited planting spaces and may serve suitably for many years. Cultivars of Callery pears (*Pyrus calleryana*) (Fig. 3) and crabapples (*Malus*) offer numerous possibilities. Not all Callery pears attain the large size of 'Bradford'. Of the hawthorns, Washington (*Crataegus phaenopyrum*), cockspur (*C. crus-galli*) and *C. viridis* 'Winter King' are used effectively in downtown areas. Around parking lots, green ash, honey locust, cut-leaf silver maple, Amur corktree (*Phellodendron amurense*), hackberry, ironwood, and globe-crown white poplar (*Populus alba var. globosa*) (Fig. 4) are appropriate trees.

Some species that tolerate adverse soil situations but often outgrow crown-limiting above-ground space are: sycamore (*Platanus occidentalis*), ginkgo (*Ginkgo biloba*), cottonwood (*Populus deltoides*), silver maple, tree-of-heaven (*Ailanthus altissima*), American elm, box elder

Figure 3. Callery pears may be used successfully in restricted planting places.

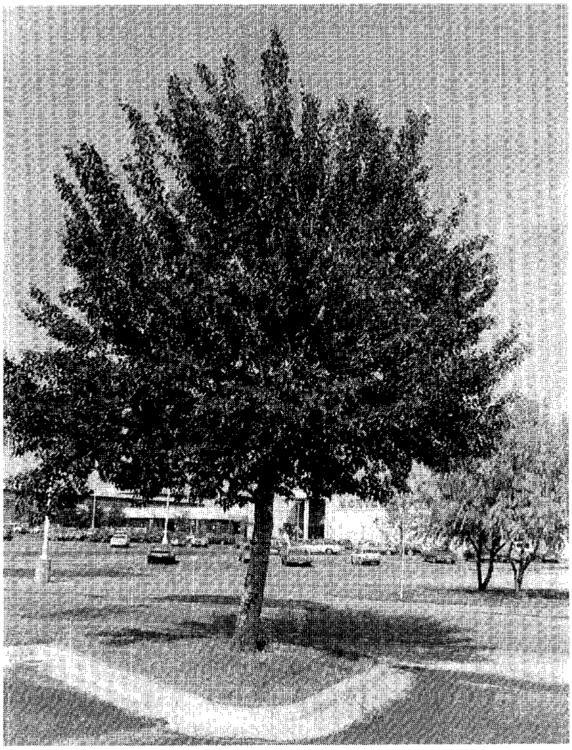

Figure 4. Globe-crown white poplars is a good selection for a restricted planting place such as this parking area.

(*Acer negundo*), and mulberry (*Morus alba*). Most of these species may be seen as spontaneous trees along urban railroad routes, in vacant lots, or on other derelict urban land.

Some examples of trees that have problems in restricted urban planting places are the following: redbud (*Cercis canadensis*), Juneberry (*Amelanchier*), fringetree (*Chionanthus virginicus*), American and European hornbeams (*Carpinus*), Russian olive (*Elaeagnus angustifolia*), red maple, and most species of *Prunus*. Some others, including birches (*Betula*), alders (*Alnus*), mountain ashes (*Sorbus*), and oaks may succumb in just a few years.

Restricted urban planting spaces range from sidewalk planting pits to patches of lawn. Limitations are usually posed by sidewalks, curbs, access drives, walls, utilities, light poles, fire plugs, and other man-made structures. Trees too often are placed in spaces that are perfunctory accommodations or are provided after building and

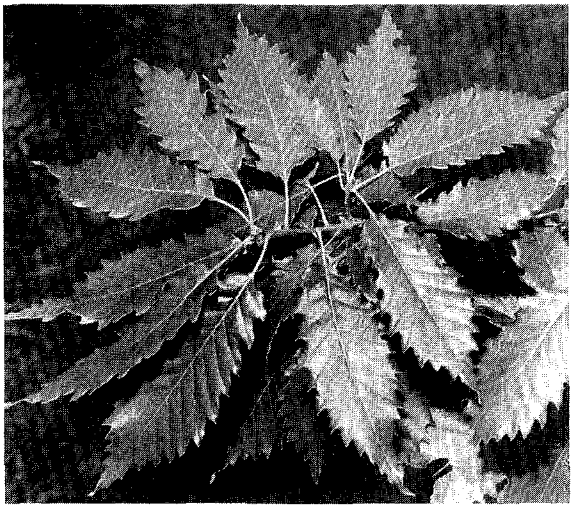

Figure 5. Chinquapin oak tolerates alkaline soil quite well.

parking-lot construction is completed. Lindsey and Bassuk (5) have made calculations of the soil volume required for meeting water needs of individual trees in restricted spaces. They developed a weather-based methodology that utilizes a U.S. Weather Bureau Class A pan for measuring evaporation. Soil volume recommendations are based upon area of crown projection to the ground. Proposals for groups of trees in large spaces or planting boxes where a few trees share rooting space, have been described by Kuhns et al. (4) and Meyer (6). Both of these papers emphasize the desirability of early planning of space for urban trees, rather than adding trees in whatever spaces can be developed following completion of construction projects.

Information on tree suitabilities has come from experience in northern Illinois, where clayey, glacially derived soils are widely prevalent. Tree-growing limitations of the regional soils of northern Illinois resemble in many ways those of the urban "soil" of many cities. The tree-selection considerations noted in this discussion have greatest applicability to the midwestern states.

Some Future Directions

Approaches to selecting and breeding trees for urban situations must deal with the limitations associated with adverse urban microenvironments and planting sites. Tough trees for tough situations must tolerate both below-ground and above-ground adversities. For example, elms, hawthorns, and poplars seldom show leaf-scorch but sugar maple, red maple, and Norway maple (*Acer platanoides*) may scorch severely in summer heat, especially in places surrounded by pavement (2). Soil alkalinity is commonly encountered in urban planting places. Tough trees for such places must be calciphytes, i.e., those kinds that can tolerate soil alkalinity (10). Chlorosis, widely associated with planted pin oaks (*Quercus palustris*), stems from the tree's inability to perform properly in soils with high pH. Some oaks such as chinquapin oak (*Q. muehlenbergii*) (Fig. 5) and bur oak (*Q. macrocarpa*) get along quite well on alkaline soil. Elms, hawthorns, and poplars also tolerate soil alkalinity.

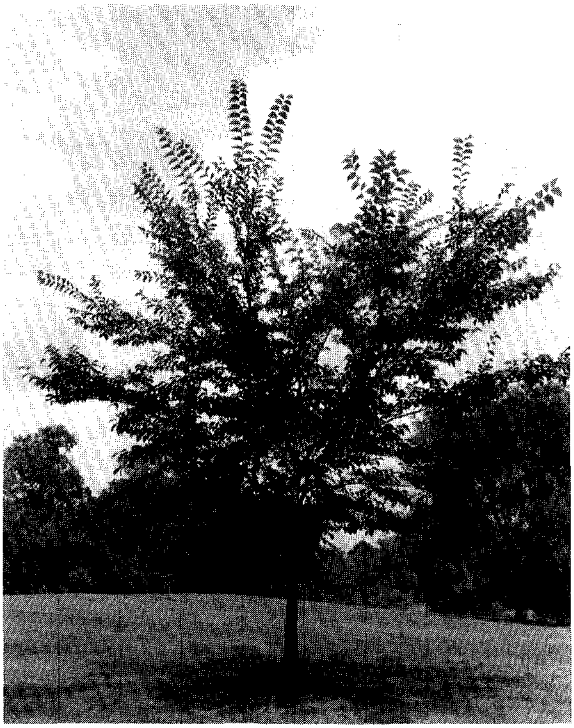

Figure 6. David elm is a small vase-shaped tree from northern China.

Tree improvement projects at the Morton Arboretum utilize species that have inherent coping capacities in urban situations. For example, the ubiquitous but inferior Siberian elm has been crossed with Japanese elm (*Ulmus japonica*) from northern China. Both parents are tough trees ecologically. Both strong wood and branches from the Japanese elm parent are imparted to hybrid offspring which appear to be promising urban trees. Crossing of silver maple with red maple produces handsome single-stem trees that cope well with alkaline soil conditions. Genetically small kinds of elms, ashes, poplars, oaks, lindens, and maples are being developed as candidates for urban use. A good example is David elm (*U. davidiana*) (Fig. 6), a small tree from northern China which appears to be a promising tree for use under power lines. This little-known elm with its broadly spreading vase-shaped crown, appears to grow well on difficult sites. It is also highly resistant to Dutch elm disease.

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Résumé. La capacité de survie des arbres urbains est intimement liée à leur «endurance» ou leur capacité inhérente de supporter le stress. La tolérance au stress peut généralement être quantifiée par l'évaluation des adversités écologiques et édaphiques de l'environnement naturel des arbres comme composante des écosystèmes. La survie et la contribution des arbres urbains dépendent de trois considérations majeures: la sélection d'arbres appropriés, le choix et la préparation d'espaces de plantation favorables, et la manutention (par exemple, transplantation correcte et bon entretien postplantation).

Zusammenfassung. Die Überlebensrate von Stadtbäumen ist eng verbunden mit ihrer 'Robustheit' oder der ihnen innewohnenden Fähigkeit, Stress zu widerstehen. Stresstoleranz kann gewöhnlich abgeschätzt werden durch *eine Untersuchung der ökologischen und edaphischen* Widrigkeiten der natürlichen Umgebung der Bäume als Teile des Okosystems. Überleben und Verbreitung von Stadtbäumen ist abhängig von drei Haumptüberlegungen: Auswahl der in Frage kommenden Bäume, Auswahl und Vorbereitung der bevorzugten Pflanzstandorte und die Behandlung (z.B. ordentliche Verpflanzung und nachfolgende Pflege).