REASONABLE GUIDELINES FOR STREET TREE DIVERSITY

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Abstract. Street tree diversity should relate to a community's range of conditions and objectives for the trees, and therefore is best increased by improved planting sites that can support more species. It is illogical to try to increase street tree diversity by simple numerical limits on replanting common, proven-adapted species if this encourages more use of unproven or less-adapted species. Alternative guidelines are suggested for evaluating local populations, determining whether common species are overused, and testing additional species. Diversity also must relate to scale. While few species may be appropriate for a particular local situation, wide promotion of species through national markets is questioned. Also, wide promotion of a few cultivars within common species is criticized in the interests of reasonable biodiversity.

The diversity of growing conditions and objectives for trees in urban areas provides a logical basis for a diversity of tree species and genotypes to serve these variables. However, a requirement that trees be adapted to the particular conditions present is more important than diversity as a goal in itself. This is especially critical for street trees for which growing conditions commonly are stressed and objectives quite demanding.

The long practice of urban tree planting from a wide variety of possible sources has resulted in many species being tried as street trees in most cities over time. But it has long been observed that most urban tree populations are dominated by a relatively few species that have proven widely adapted and useful in that community, and small numbers of many species with narrower adaptation and use there. Solataroff in 1911 recognized this reality in his classic book on shade tree management (8). It was not surprising to the pioneer New Jersey shade tree commissioner that only a limited number of species could withstand city conditions, were long-lived, and were otherwise suited as street trees. He cautioned about use of new or unproven species, and suggested one of the best ways to decide on trees to plant is "to note the trees in one's vicinity and see which do best." His observations were largely revalidated in our evaluation of diversity and stability in the street tree population of Syracuse New York from 1951 to 1978 (5), and have been reinforced by observations here and elsewhere since then.

Recent popular interest in biologic diversity has taken a strange turn in being translated to urban tree populations. Informed concern for biodiversity generally centers on providing or maintaining habitats and other conditions favoring survival of less-common species. For urban areas, this would mean developing better greenspaces and tree planting sites capable of supporting a greater variety of trees and other biota that we might value there. But among some working with urban tree populations, concern for biodiversity is translating to emphasis on species eveness or equity as a goal for urban areas to be achieved by reduced planting of common, widely adapted species. The extreme of this is an oft-repeated standard that no species should comprise more than 5% of a community's street tree population. This was slightly broadened by Miller and Miller (4) recommending that "liberal use" of a species should not exceed 10%. More recently, Jaenson et.al. (3) suggested that city foresters should use species percentages derived from rapid, sample surveys to "reassess their recommended species lists to achieve a 5%-10% ceiling on any one tree species".

These simple numerical limits have no scientific basis that I can find, and they may be irresponsible guidelines if they result in substantial replacement of proven-adapted species by poorer-adapted or unproven species for the sake of species equity. In addition to arguing that species equity is a poor standard by itself, the main purpose of this paper is to suggest some more reasonable guidelines for diversity concerns in street tree populations.

Species Diversity in Forest and Urban Stands

Many or most natural forest stands also are dominated by a relatively few species. Foresters commonly list the species comprising over 10% of a stand to describe the "cover type" that largely determines the functional character of the stand. As a generality, highly favorable environments for tree growth tend to have a larger number of species sharing dominance in any particular stand; humid tropical forests often being noted as an example of this. Many forests with moderately favorable conditions have "guilds" of species with similar functional characteristics, and the predominant guild species in a particular stand depends on local circumstances. It is also fairly common for a single species to make up over half the composition of natural stands, especially where there are significant environmental constraints. Although shade and shade-tolerance are important forest constraints that are less important for street trees, natural forest constraints of local climate stress and shallow, droughty, or poorly-aerated soils obviously have their streetside parallels.

While it is useful to recognize that predominance of only a few species in a street tree population is not an "unnatural" phenomenon, species diversity in natural stands is otherwise a poor model for street tree populations. Natural tree mixtures normally result from hit-or-miss multiple seeding from available sources onto varying sites. Along with plant successes, these mixtures reflect many misses as well as "poor hits" of plants not really well adapted to the conditions in which they are growing. We cannot afford to imitate hit-or-miss in street tree populations, but rather must try to give each planted tree a high probability of success.

Because of the diversity of conditions and objectives in urban areas, single-species, or "monoculture" tree communities rarely occur in cities at the scale they do among planted forest stands. Nevertheless, even moderately heavy dependence on one or few species tends to make urban tree managers nervous because of the relatively high stakes riding on urban trees. In the USA, the loss of elms to Dutch elm disease (DED) is the commonly cited example because the high dependence on elms in many communities made the loss catastrophic in at least the short run. In most cases, a number of replacement species were tried both to seek a substitute for the lost elms and to avoid such heavy dependence on one species again.

In most communities where elms were previously important, no full replacement has been found for their basic values as broadly -adapted, vigorous, street-tough species with high, light crowns that caused relatively little conflict with street-level activities. To a large extent tree managers have shifted standards to more modest-sized trees that, ironically, may cause more street-level conflicts. Detailed study of replacement plantings in Syracuse, where elms were 41% of the street trees in 1951 before DED, has shown only a few of the many species tried have proven widely successful. On the other hand, we now know a number of species to be either of limited value or unsatisfactory as street trees here.

The "elm specter" deserves critical examination as an argument against relying heavily on a few proven-adapted species. Elms served well as street trees for 50 to 80 years or more in many communities, so it is not logical to deem them a mistake in hindsight. The fatal defect of our native elms was that they were susceptible to an introduced disease which decimated natural populations as well as street trees. We now know we could have managed DED better to slow loss rates to more tolerable levels, and are doing this in some residual elm populations. American tree enthusiasts also sadly note the earlier nearly complete loss of American chestnut, *Castanea dentata,* from our natural forests due to an introduced disease. The defect was not that the species was once common, but that it did not contain genetic resistance or resilience to the disease, as is present in other chestnut species. A very different pest situation is the gypsy moth, *Porthetria dispar*, so adaptive as an introduced insect that avoiding susceptible trees would seriously curtail our species choices. Sustained management of tree populations in the face of shifting biotic environments and other uncertainties can involve many strategies besides making useful, adapted species less common.

Evaluating Local Species Adaptation

In many urban areas, a major constraint to evaluating local street tree performance to determine species suitability for replacement plantings is the poor continuity of information over the community's tree history. The tenures of most urban tree managers and organized tree programs have been too short to gain good perspective over time, and tree evaluations made in the past tend either to get lost or not be very reproducible for evaluating changes. One-time tree surveys can be useful to identify current conditions and treatment needs, but have limited value by themselves for evaluating the dynamics of adaptation. Hopefully, increased recent activity in street tree inventories will result in more useful reference information in the future.

Our street tree studies in Syracuse have been fortunate in being able to make species comparisons of our detailed 1978 inventory with the 1951 inventory by Dr. Howard Miller as well as his personal perspectives; and we now have 15 years additional field observations. Comparison of species distributions among size classes in our 1978 inventory gave clues to adaptation, but additional information has been needed for useful interpretations. Some of our Syracuse findings are given here to illustrate the information use for interpreting street tree adaptation in a community. Species noted are not intended as recommendations for other communities.

In 1951, Norway, silver, and sugar maples (*Acer platanoides, A. saccharinum,* and *A. saccharum*) shared dominance of the street tree population with the elms in Syracuse. Norway maple had become a popular street species after about 1915, whereas many of the elms and silver and sugar maples were older. In 1978 after loss of most elms and a major replanting program, the three maples were 55% of the total street trees, but 84% of the trees over 40 cm diameter, demonstrating their long-term success. The Norway maples generally have been maturing and deteriorating younger than the silver and sugar maples, so all three species are now being removed at a greater rate than their replanting. While each of these maples has limitations that need to be recognized in site selection, their proven adaptation and longevity make them logical species to continue replanting in Syracuse where appropriate.

Several other species planted for some time, but less than the maples, are now also mostly in the larger size classes. This suggests good biotic adaptation and longevity, but less planting recently for various reasons. Some, such as *Populus deltoides* and related poplar hybrids, are now acknowledged to be unsuitable for streetside planting. Several other species, including basswood (*Tilia americana*), native sycamore (*Platanus occidentalis*) and the introduced horsechestnut (*Aesculus hippocastanum*) have proven at least selectively adapted as street trees here, but have been bypassed in recent species promotions. Such species are reasonable candidates for greater use where appropriate because their local values and limitations are already known.

Several species long planted in Syracuse have not persisted to the larger size classes but are prominent in smaller sizes due to continued planting. These include red maple (*Acer rubrum*), London plane(*x Platanus acerifolia*) and ginkgo (*Ginkgo biloba*), which have had relatively poor longevity on Syracuse streets, as well as naturally small trees such as crabapples (*Malus spp.*). The deficiencies of these species require careful evaluation. They can be useful in certain situations. Otherwise, they may represent undesirable diversity in the street tree population if they contribute less benefit than their costs.

Several species that were rare or absent among older street trees in Syracuse were planted for elm replacement in sufficient numbers to permit local evaluation. Most were less than 10 years from planting when examined in 1978, so serious failures could be identified but successes had to be rated tentatively. Now, many of the survivors of recently tested species are over 20 years from planting, so we can judge them better. For example, *Zelkova serrata,* and most *Prunus* species have proven ill-adapted to Syracuse streets; honeylocust (*Gleditsia triacanthus*) and little-leaf linden (*Tilia cordata*) appear biologically-well-adapted and valuable for several street situations; while *Sophora japonica* and some recent callery pear cultivars (*Pyrus spp.*) look promising for certain street situations but need longer evaluation in Syracuse.

Because of the high probability of new species proving unsatisfactory or of limited value on local street sites, it is wise to hold new species to a total proportion that would not disrupt population management if they do fail. However, no general percentage limit should be set because this depends on specific circumstances. It seems unwise to test any unproven species on difficult sites with high public use, but it may be quite reasonable to experiment with several new species on good outer-city streetsides if there is local interest in tree diversity.

When is a Species Overused?

In communities old enough for their tree populations to have developed through trial and error, a species that is more than 10% of the street trees is likely to be fairly widely adapted to that community's conditions and objectives, and also its liabilities there probably are well known. What then is a rational limit to the use of a common species? I suggest that, regardless of percentage, a species might be considered "overused" if it is often planted where other proven species are likely to be better suited. But one can hardly fault making "safe choices" for critical planting sites. A logical response to species that predominate due to their proven adaptation is to constrain additional plantings to situations where they are believed to be the best available choice, and encourage suitable alternatives elsewhere. This may result in a reduced planting rate for a common species, but its relatively high success rate will maintain its prominence in the population.

The problem of few proven choices is illustrated in Syracuse's downtown area where most tree planting sites are inadequate and trees are subjected to heavy damage, as in many cities. To aid planting decisions for major downtown rehabilitation in Syracuse, in 1991 I repeated our detailed 1978 street tree inventory of that area. Our previous data and interim observations permitted identifying survival and growth of individual trees over the 13 year period. The area had 313 street trees in 1978, of which 57% were honeylocust, 21% London plane, 9% Norway maple, 5% littleleaf linden, and 7% several other species. Eighty percent of these honeylocust were still present in 1991, with most growing reasonably well considering the severe street impacts. London plane,and linden had fair survival justifying their continued use if the planting sites are improved, while Norway maple clearly is less suited to downtown streets than elsewhere in Syracuse. Except for some sophora, no other planted species had survived from 1978. From continuing plantings and additions, 202 post-1978 trees were surviving in 1991. Half of these were honeylocust; bringing this species to 61% of the 409 trees growing there in 1991. Streetside rehabilitation plans called for planting species by streets, with marginal improvement of planting sites. However, not enough proven species could be identified to assign a different one to each street. It was logical to choose honeylocust for the most constrained main street, and also a different honeylocust cultivar for one side street. Some other species had to be selected on less basis of proven performance downtown. Conversely, it is logical to promote several alternatives to honeylocust for relatively favorable outer-city streets in Syracuse.

Simple percentage limits on species do not safeguard a population from poor species choices. Ill-adapted species can be a problem at only a few percent of a large street tree population. In our 1978 inventory of Syracuse streetsides, various crabapples were 5% of the street trees but were one of the most common genera identified as improperly sited on street strips. Crabs and other small trees have been over-sold for planting under street wires where there is inadequate space to train a tree past the wires. These trees necessarily have low crowns that can seriously interfere with street-level activities and safety. They are best suited for wide planting strips in lower activity areas where larger trees may also be suitable. Crabs, along with most other dwarf species, also require relatively high maintenance in relation to their benefits. These species have very limited utility as street trees in Syracuse, although other communities may have more street conditions satisfactory for their use.

Diversity Relates to Scale

Population scale must be considered in evaluating species diversity. There are advantages to having a single species on a street block provided it is a good choice for that block. A few species mixed on a street also can be manageable and perhaps more interesting, but require that the species be compatable as well as all adapted to the site and objectives. High diversity at the local street scale is more difficult to manage and increases the chance that some of the species are poor choices. While different street situations may warrant different species choices, the limited number of good solutions usually requires repeating effective patterns over an urban landscape, just as is common in rural and wild landscapes.

As species richness partly depends on the scale of plant community observed, a larger number of adapted species usually can be found in an entire urban area than in a neighborhood. Communities in a region may show similarities in tree responses but other differences in tree populations based on community structure and history. For example, tree conditions in central New York villages near Syracuse are only partly a miniature of the city. The small-scale business centers provide nearly as poor conditions for tree growth as the city downtown, while village residential areas have tended to treat trees more casually, often as"roadside trees" more than "street trees."The older trees in the villages are more traditional, sugar and silver maples more than Norway maple, but recent plantings are similar in village and city because they now use the same sources of information and nursery stock (6).

Greater concern for street tree diversity should be directed to the broad regional and national scale where easy flow of information may be promoting too-general solutions for tree planting decisions. Tree lists developed in a particular area tend to be used more broadly than warranted. For example, a tree list based on careful studies in Ohio (1) received wide publicity, but some of the recommended Ohio species are poor or marginal in central New York. Even within New York, there are major differences in species adaptation among climate and soil regions. Again, the best information on local adaptation is likely to be in the local tree population and its history. But often, people with limited local experience are in the position of making species choices for communities. Compiled regional information such as the "Street Tree Factsheets" (2) in the northeast USA is valuable to identify species characteristics to be checked on locally, but should not be taken as recommendations without local interpretation.

Biodiversity Involves More Than Species

"Species" should not be the only level of concern with street tree diversity. Widespread natural species usually have substantial genetic variation within the species, which may be as important for their street tree function as the differences between some species. Whereas early street tree populations included many seedling trees, often locally collected, common species now are represented in the nursery trade by relatively few cultivars distributed widely. The national scale of the nursery industry and cost of developing and testing cultivars has discouraged marketing large numbers of cultivars tailored to different street tree conditions. On the other hand, seedling populations often have more variation than desirable on streets where each individual is important, compared to managed forest plantings where only a fraction of the original trees are chosen for the desired mature stand. Hopefully, new micro-propagation and other biotechnology techniques developing for various plant crops can be applied to expanding "controlled biodiversity" available within street tree species. This is likely to be more important in the long run than adding new species to street tree populations.

An important outcome of more attention to within-species diversity should be improving species that have wide biotic adaptation but other deficiencies as street trees. Honeylocust became a useful street tree only after thornless cultivars were developed; but now a broader cultivar pool for honeylocust appears desirable. The wide biotic adaptation of silver maple in the USA justifies developing cultivars with this species' resilience but more moderate growth and crown form like sugar maple. In Syracuse, where most of the largest street trees are silver maples over 100 years old, their major deficiency is excessive size and sprawling form in relation to limited street spaces. However, some trees with more self-controlled form are evident in the population.

Santamour and McArdle (7) catalogued over 50 valid cultivars of silver maple, but most have been selected for leaf features more than tree form. As there are very practical constraints on how much we are likely to improve urban streetsides to support a greater diversity of tree species, we need to capitalize more on the biodiversity within adapted species to serve the variety of conditions and objectives for street trees in our communities.

Summary

Street tree diversity should relate to the range of conditions and objectives in a community rather than to simple numerical standards. Species adaptation to local conditions is more critical than diversity per se. Species equity is not a reasonable goal for most street tree populations because few species have equally wide adaptation to the range of street conditions present in most urban areas. It is natural and not inherently bad that a few species predominate in street tree populations due to their broad adaptation. At any proportion of a local population, a species might be regarded as "over-used" if it is often planted where other proven species could serve better. This should not preclude substantial use of a proven species in local situations where it is judged to be the best known choice. Increasing diversity beyond the proven-adapted species requires adding either unproven or less-adapted species. The added species are best tried on favorable sites where they have the best chance, and also used in small enough numbers so that failures will not disrupt population management.

Evaluation of species diversity must consider scale. It is reasonable to use one or few species for a specific local situation, and a somewhat larger number of species to meet the range of street situations in a large urban area. In this respect, we should be more concerned about widespread promotion of particular species as street trees for diverse urban areas over a region or country. The best information on local suitability as street trees is likely to come from species performance in that community or similar conditions in nearby communities. General species descriptions and ratings from elsewhere should not be considered as recommendations until evaluated for local conditions. Also, narrowed genetic diversity within species resulting from widespread use of relatively few cultivars should be of at least as great concern as species diversity. An increase in "controlled biodiversity" commercially available within common street tree species could be more important in the long run than additional species for testing in local street tree populations.

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Résumé. La diversité en arbres de rues devrait s'ajuster, au sein d'un communauté donnée, selon les diverses conditions en vigueur et objectifs souhaités par ces arbres, et par conséquent est la plus accrue par l'amélioration des sites de plantation qui peuvent accueillir plus d'espèces. Il est illogique de tenter d'accroître la diversité en arbres de rues par l'instauration de limites numériques sur des espèces bien éprouvées et communément utilisées pour le remplacement si cela encourage l'emploi accrû d'espèces d'adaptation moyenne ou non éprouvée. Des lignes directrices alternatives sont suggérées pour évaluer les populations locales afin de déterminer si les espèces communes sont suremployées et aussi de mettre à l'essai de nouvelles espèces.

Zusammenfassung. Die Vielfalt der Strassenbäume sollte sich beziehen auf die Lebensbedingungen in einer Gemeinde und die Aufgabenstellung für die Bäume und kann daher am besten gesteigert werden durch eine Verbesserung der Pflanzflächen, die viele Arten vertragen. Es wäre unlogisch, zu versuchen, die Vielfalt zu vergrößern indem man die Anzahl der Neupflanzungen von bereits bekannten und erprobten Baumarten limitiert, wenn das letztendlich zur Pflanzung von weniger erprobten Baumarten limitiert, wenn das letztendlich zur Pflanzung von weniger erprobten und weniger angepassten Arten führt. Es wurden alternative Richtlinlen vorgeschiagen zur Bewertung von lokalen Populationen, zur Bestimmung von der Übernutzung der Arten und zum Testen von zusätzlichen Baumarten.