TREES FOR URBAN PLANTING: DIVERSITY UNIFORMITY, AND COMMON SENSE

FRANK S. SANTAMOUR, JR.
U.S. National Arboretum
Agricultural Research Service
U.S. Department of Agriculture
Washington, D.C. 20002

ABSTRACT -- A broader diversity of trees is needed in our urban landscapes to guard against the possibility of large-scale devastation by both native and introduced insect and disease pests. Urban foresters and municipal arborists should use the following guidelines for tree diversity within their areas of jurisdiction: (1) plant no more than 10% of any species, (2) no more than 20 % of any genus, and (3) no more than 30 % of any family. Strips or blocks of uniformity (species, cultivars, or clones of proven adaptability) should be scattered throughout the city to achieve spatial as well as biological diversity. Terms such as “monoculture”, "cultivar", and “clone” are discussed and a rationale is provided for the planting recommendations. The potential problems of graft incompatibility in some species are considered in the light of recent research.

The widespread planting of American elms in the towns **and** cities of eastern United States by our forefathers was not a stupid idea. Rather, our early horticulturists were simply taking advantage of the beauty and adaptability of a native tree that Thomas Jefferson called “Nature’s noblest vegetable”. The accidental introduction of Dutch elm disease and the consequent destruction of millions of city trees served not only to focus attention on urban forests but also to spur efforts to find “replacements” for American elm. We will not, and indeed should not, “replace” American elm with any single tree species in the quantities previously allotted to American elm.

We need a diversity of trees in our urban forests, not only to guard against disasters like Dutch elm disease, but also to “put the right tree in the right place” as the evolution of our cities and suburbs creates new sites and settings for tree planting.

THE TEN-PERCENT SOLUTION

In recent years, there has arisen a dictum that “Thou shalt not plant more than 10% of any species” in a particular area. Generally, that area is undefined, but for a municipal arborist or city forester it can be interpreted as being within the boundaries of his or her responsibility. I am not sure who first propounded the "10% rule", nor am I sure that anyone would want to take credit for it, but it is not a bad idea. Still, in an "ideal" city of 100,000 trees, 10,000 trees of each of 10 species does represent a modicum of uniformity.

The "10% rule" is a reaction to the possibility that some major insect or disease pest could, at some point in time, virtually wipe out the trees in a city. In general, the rule is considered a safeguard against a "new pest" that might be introduced from a foreign country. The American experience with Dutch elm disease and chestnut blight is sufficient to explain our concern about such epidemics. More recently (although the jury is still out in regard to its origin), the continuing spread of dogwood anthracnose disease on our native Cornus florida has caused great alarm.

There are also many "native" insect and disease problems that we are well aware of and must consider as potential threats to the urban forest. While a complete listing of such pests is beyond the scope of this paper, a few examples may suffice: oak wilt and obscure scale on oaks, fire blight on trees of the rose family, borers in white and green ash, sycamore anthracnose on Platanus species and hybrids, and the elm leaf beetle on **elms.** Some of these pests can be lethal, but all pests may contribute to the suboptimal growth and appearance of host trees.

In addition, there are also many known pests, native and introduced, with such a broad host range that a diversity of species, or even genera, will not discourage them. Among these are the gypsy moth, "evergreen" bagworm, Japanese beetle, Armillaria root rot, Verticillium wilt, and various nematodes. Thus, while the "10% rule" may serve as a target or goal to soothe the consciences of city councils and municipal arborists, it will not solve all potential pest problems nor guarantee the long-term stability and esthetics of the urban forest.

If we are to plant and sustain city forests that will delight and inspire the residents and visitors in our urban centers, we need both diversity and uniformity of plant material to reduce the costs of maintenance and reduce the use of potentially dangerous pesticides. We need to plant more of the superior trees developed through genetic research. We need to utilize the practical experience of experienced practitioners of urban forestry. We have to plan the planting of city trees, and understand the problems and potentials of our actions.

The l0-percent solution, while it seems to be reasonable, simply does not address the realities of host-pest relationships.

MONOCULTURES, CLONES, AND CULTIVARS

To begin, let us deal with a few terms that must be properly understood if we are going to communicate our thoughts and results.

It is almost universally agreed that tree monocultures are bad, even though those who espouse this wisdom may not agree on what a monoculture really is. I have purposely not looked up "monoculture" in the dictionary. I am not even sure that the term can be found in the dictionary. Despite this self-imposed lack of knowledge, let me say that monocultures may not necessarily be bad, and may, in fact, be good. If we can start with the premise that a monoculture consists of large numbers (hundreds, thousands, millions) of plants of the same species growing in a restricted area, we would have to conclude that monocultures are the fundamental basis of agriculture. Without these monocultures of wheat, rice, maize, or even broccoli, our world could not exist. (On the other hand, the monoculture of Homo sapiens as the prevailing intelligent life form on planet Earth has been responsible for disasters of far greater magnitude then Dutch elm disease).

A clone consists of a group of plants of absolute genetic uniformity, from root tip to apical meristem, and is the ultimate in monoculture. Few, if any, of our major crop plants are currently clones, but with increased success in biotechnology, some will certainly be cloned in the future. Farmers are not afraid of clones, or of species monocultures with minimal genetic diversity. There are several reason for agriculture's reliance on genetic uniformity. One of the principal reasons is that most crop plants grown on a large scale are the products of generations of genetic research to breed and select plants that are resistant to major pests and are adaptable to specific localities. The inherent superiority of these plants and the uniformity of reliability in sowing, culture, and harvesting demand monocultures. Also, most agricultural plants are annuals, and if pest problems do arise, an army of scientists is ready to battle the pest, usually successfully, with new genetic combinations, chemicals, or biocontrol agents.

The city forester is not as fortunate as the farmer. Few trees currently grown and sold as clones in the nursery trade have been purposely developed and thoroughly tested for pest resistance. The trees must endure for decades in often difficult situations where environmental and biotic stresses are continually changing. The development of a new "replacement" for a clone, with similar characteristics of growth and pest resistance may require decades of research.

Some of the clones (trees on their own roots) now available for city planting were originally selected for certain esthetic reasons, propagated by budding and grafting, and marketed as named cultivars. Clones may not be cultivars, and cultivars may not be clones: and the distinctions between clones and cultivars have been discussed in an earlier paper (Santamour, 1976). All it takes to make a clone a cultivar is the application of a name to that biological entity. All it takes to make a grafted cultivar a clone is to put it on its own roots.

A grafted cultivar is genetically uniform above ground, and it is likely that all trees of a given cultivar will possess the same degree of resistance or susceptibility to biotic or abiotic influences. However, the use of seedling understocks, whether of the same or a different species, introduces an element of diversity that might affect tree performance. Certainly, one of the major functions of a root system is the absorption and transport of water and mineral nutrients to the tree. Genetic variation among rootstocks must have profound effects on cultivar performance. Of course, those effects are seldom so drastic that the distinctive morphological characteristics for which the cultivar was originally selected are altered to the point that the cultivar is no longer recognizable.

In summary, tree monocultures may only pose major problems when the numbers of trees are large and the area occupied by the trees is restricted. Twenty to fifty trees of a single species, or even a single clone, planted along a few blocks of city streets do not constitute a “dangerous” monoculture. Genetic uniformity within a species is to be desired, especially when the clones, cultivars, or seedlings have proved to possess certain desirable characteristics. Genetic diversity is achieved by mixtures of uniformity, and will be discussed later.

ADVANTAGES OF CULTIVARS

The most obvious advantage of cultivars is their reliability, especially those cultivars that have been in the nursery trade for 20 years or more. They can be counted on to develop the form, color, and growth rate for which they were selected. Their longevity in the trade and their widespread planting have provided the testing necessary to determine both their good and bad characteristics. The urban tree planter knows what to expect of such trees.

One other characteristic of most cultivars, especially those that had been traditionally propagated by budding and grafting, is their genetic capacity for strong wound compartmentalization. Our studies (Santamour 1984, 1986)) have shown that every cultivar tested, in a wide range of genera and species, were strong compartmentalizers. The conclusion was made that the grafting and budding process constituted an inadvertent “screening” and only strong compartmentalizing trees would be amenable to long -term commercial propagation by these techniques. Some of the cultivars formerly propagated by budding and grafting are now propagated on their own roots and have, of course, retained this important trait. On the other hand, cultivars of genera or species that had traditionally been propagated from cuttings (e.g. poplars, willows) were not subject to the "screening" process and may be either weak or strong compartmentalizers.

UNCERTAINTIES OF CULTIVARS

The major uncertainties of cultivars relate to the possibility of long -term graft incompatibility. Recent work in our laboratory (Santamour 1988a, 1988b, 1988c, 1989) has determined that intraspecific graft compatibility is dependent on the similarity of stock and scion in cambial peroxidase enzymes, which mediate the production of lignin. In the species we have studied intensively (Castanea mollissima, Quercus rubra, Acer rubrum) and in which graft incompatibility was a major problem, there was considerable tree-to-tree variability in enzyme patterns. On the other hand, some species appeared to be quite uniform in enzyme pattern (Acer saccharum, Acer platanoides, Gleditsia triacanthos) and no graft incompatibility has been reported. Limited work on Comus, Fagus, Fraxinus, and Koelreuteria indicated that graft incompatibility could cause problems in these genera.

For those genera and species that are difficult to propagate from cultivars or by micropropagation, the careful matching of enzyme patterns of stock and scion will produce graft-compatible combinations. However, there ate still many species that have not been studied, and the city forester should not only be cautious in their use of new grafted cultivars (in, for example Celtis, Maclura and Tilia) but also learn to observe and evaluate graft incompatibility as a probable cause of poor performance in the landscape.

INTRA-SPECIFIC DIVERSITY

Below, I have listed the various levels of diversity within a species, from the most uniform to the most diverse. We do not need or want a great deal of intra-specific diversity in our city plantings. Such diversity will not protect us from pest -related disasters. The entire range of natural intra- specific diversity in American chestnut and American elm did not deter the spread of chestnut blight or Dutch elm disease. We do want uniformity within species; the uniformity of adaptability, survival, and performance that knowledge of plant origin and experience can provide us.

1. Clone: Propagated by rooting cuttings or micropropagation from a single plant. All members of the clone will be genetically identical from root tip to apical meristem. More often than not, a cultivar name will have been given to the clone.

2. Cultivar: In landscape trees, generally propagated by budding or grafting scions from a single plant on seedling rootstock of the same species. The above ground portion of all trees will be genetically identical, but there will be genetic variability among rootstocks. Cultivars are named selections.

Graft incompatibility can cause problems.

a. Some fruit trees are budded or grafted on vegetatively -propagated (clonal) rootstocks, so there is genetic uniformity both above and below ground.

b. Some landscape trees are budded of grafted on seedlings of a species different from that of the scion. Thus, the degree of genetic variability below ground may be greater than if seedlings of the same species were used.

3. Seedlings derived from seed collected from a single tree. Granted that most landscape trees are naturally cross-pollinated and are highly heterozygous, the progeny from a single parent tree will be more genetically uniform than seedlings derived from several parent trees.

4. Seed-Orchard Seedlings: Seedlings derived from in&pollination among trees selected for certain desirable attributes (such as pest resistance) and propagated and planted in a "seed orchard", specifically for seed production. There will be a high degree of genetic uniformity with regard to the traits that constituted the origionaI selection criteria but, still, a reasonable amount of genetic diversity.

5. Provenance Seedlings: Seedlings from native trees in a particular geographic area, assuring that the seedlings will be adaptable to the general climatic conditions pertaining in that area.

6. Mixed Seedlings: Seedlings of unknown geographic origin with unknown adaptabilities or seedlings of different known provenance. This potentially high level of diversity may occur among the products of a single nursery and will nearly always occur when seedlings must be obtained from several different nurseries.

INTERSPECIFIC AND INTERGENERIC DIVERSITY

If we arc really going to plant and manage the urban forest to minimize potential pest problems, we must look at host-pest relationships. Pests tend to follow the taxonomic categories of host plants at the species, section, series, genus, or family levels. Let us consider the genus as the major taxonomic category. The fact that we refer to many pests with host-generic names (Dutch elm disease, oak wilt, bronze birch borer, maple anthracnose) indicates that many species of the host genus are susceptible to those pests. Thus, the "10% (species) rule" offers little protection against potential epidemics. Could we amend the " 10% rule" to include genera?

In a way, we have already done this. In many genera, only a single species in widely planted in urban landscapes: Ginkgo biloba, Gleditsia triacanthos, Pyrus calleryana, Tilia cordata, Sophora japonica, Liriodendron tulipifera, Liquidambar styraciflua, Zelkova serrata. This is intergeneric diversity. There are relatively few tree genera in which there are several species with proven value as urban trees, most notably maples (Acer) and oaks (Quercus). The maples are divided by taxonomists into about 20 botanical sections, and the oaks into five subgenera, With few exceptions, hybridization between species belonging to these different categories does not occur; thus there may be important genetic differences among such species, The three most widely planted maples (Acer rubrum-red maple, **A.** saccharum -sugar maple, **A.** platanoides -Norway maple) belong to three different sections, yet they are all susceptible in some degree to maple anthracnose disease. We know that red oaks (subgenus Ervthrobalanus) may be more susceptible to oak wilt than the white oaks (subgenus Lepidobalanus) and that white oaks may be more susceptible to gypsy moth than red oaks. But there are notable and important exceptions to this generalization. Therefore, the quantity of trees planted in any particular genus must also be limited.

The next taxonomic category above the genus is the family. Generally, in urban America, trees of one genus of a particular family are planted in preference to others, e.g.: more Quercus than Fagus (beech) in the Fagaceae, more Betula (birch) than Alnus (alder) in the Betulaceae. There are, however, two large families that must be considered, the rose family (Rosaceae) and the legumes (Leguminosae or Fabaceae).

Leguminous trees include Albizia, Cercis, Cladrastis, Gleditsia, Gymnocladus , Labumum , Maackia, Robinia, and Sophora. Actually these genera can also be classified in three subfamilies or, indeed, into three separate families and there may be limited similarity among genera in host-pest relationships. Still, both Gleditsia triacanthos and Albizia julibrissin (mimosa) arc highly susceptible to the so-called mimosa webworm.

Tree genera in the Rosaceae include Amelanchier , Crataegus , **Malus ,** (mostly crabapples in urban planting), Prunus (mostly cherries), Pyrus (mostly **P.** calleryana), and Sorbus. It would be extremely difficult to apply the "species" rule to the various cultivated Crataegus, Malus, and Prunus since "many (if not most) of the cultivars of these genera are really interspecific hybrids of unknown parentage, Of greater importance, however, is that trees of Amelanchier, Crataegus, Malus, and pyrus are all potentially susceptible to the bacterial disease "fire blight". It is, therefore, likely that a "new" disease or insect pest may find a wide range of hosts in this family.

Thus, we can see that genetic diversity within a species is no safeguard against potential pest problems, generic diversity is most important, and family diversity must also be taken into account.

THE 10-20-30- FORMULA

For maximum protection against the ravages of "new" pests or outbreaks of "old" pests the urban forest should contain:

1. No more than 10% of any single tree species.
2. No more than 20% of species in any tree genus.
3. No more than 30% of species in any tree family.

COMMON SENSE

For uniformity, use clones and cultivars that have been in the nursery trade for a long time and that have proven their reliability. Use some of the newer introductions that have been developed through scientific research and that have been selected for survival traits such as pest resistance or salt tolerance. Use, somewhat cautiously and on a trial basis, some of the untested new cultivars of "unfamiliar" species or genera such as Celtis or Maclura.

For uniformity, use seedlings of known geographic origin (or, in the case of exotics like Tilia cordata, from proven seed sources) so that the plants will be able to tolerate the general climatic conditions in your area.

For diversity, use the best clones, cultivars, and seedlings of many species and genera either as scattered strips or blocks of uniformity distributed throughout the city or as mixtures of individual trees along parkways and in parks.

For the education of The Next Generation, plant a catalpa, a hickory, a horse-chestnut, a sassafras, and even a thorny honeylocust in park areas that can and should be used to stimulate an interest in the diversity of Nature.

LITERATURE CITED

Santamour, F.S., Jr. 1976. Clone vs. cultivar: the root of the problem. Amer. Nurseryman, 144 (4): 20, 36.

Santamour, F.S., Jr. 1984. Wound compartmentalization in cultivars of Acer, Gleditsia, and other genera. J. Environ. Hort. 2:126-128.

Santamour, F.S., Jr. 1986. wound compartmentalization in tree cultivars: addendum. J. Arboriculture, 12:227-232.

Santamour, F.S., Jr. 1988a. Graft compatibility in woody plants: an expanded perspective. J. Environ. Hort. 6:27-32.

Santamour, F.S., Jr. 1988b. Graft compatibility related to cambial peroxidase isozymes in chinese chestnut. J.Environ. Hort. 6:33 -39.

Santamour, F.S., Jr. 1988c. Cambial peroxidase enzymes related to graft compatibility in red oak. J. Environ. Hort. 6:87-93.

Santamour, F .S,, Jr. 1989. cambial peroxidase enzymes related to graft compatibility in red maple. J. Environ. Hort. 7:8- 14.