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MIXING SPECIES OF SHADE TREES FOR BEAUTY AND SAFETY[1]

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Anyone travelling in southern New England cannot fail to have seen at first hand good reasons for diversifying the species used in street tree planting. There have been scattered but severe outbreaks of gypsy moth, a pest which is said to be omnivorous but which has very definite food preferences. While oaks and maples in infested areas have been defoliated, tulip trees, sweet gum, magnolias, and white ash growing beside them have not been touched. Similarly in New Jersey, which has experienced tent caterpillar injury, wild cherry and crab apples were severely defoliated while callery pear, dogwood, magnolias, and silver bell did not lose a leaf. On a slower scale but nonetheless a serious progression, one parkway on Long Island which was planted with Austrian pine as the only conifer is gradually losing them all. In contrast, another which has a distribution of species including white pine, Japanese black pine and Norway spruce is also losing some Austrian pines, but the visual impact is minimal.

The planting of mixed species of trees on city streets is certainly not a new concept, although it is only now beginning to receive serious consideration. Indeed, from the ecological point of view, it is as old as trees themselves.

Throughout both the tropical and temperate zones of the globe, most forests are composed of several to many tree species, as well as an even more mixed understory of many kinds of shrubs and herbaceous plants. In a sense, this diversity of species composing a wild forest can be thought of as nature's insurance policy for forest preservation in the face of the inroads of both insect pests and fungus diseases.

For example, few present-day arborists realize the past importance of the American chestnut (Castanea dentata) to eastern forests. Few species surpassed it in abundance and commercial importance. It was the single most important component of the mast upon which many kinds of wildlife fattened in the fall in preparation for the rigors of the winter months. Had the chestnut been this country's sole forest tree, the ravages of the introduced chestnut blight (*Endothia parasitica*) would have been catastrophic. The damage was serious, but, because of the diversity of the forest tree population, the disappearance of the chestnut is not noticed today. The other species have simply moved in to take its place.

From an arboricultural point of view, the decline of the American elm (*Ulmus americana*) was much more significant than that of the chestnut. But, with this tree, part of the problem was caused by human error. The American elm was almost an ideal street tree in many ways. It was hardy, tolerant to a wide variety of soils and climates, easy to transplant and both rapid-growing and long-lived. It was so good that, in far too many cities and towns, it was the only species planted.

When the Dutch elm disease (*Ceratocystis ulmi*) was accidentally imported on logs from Europe, along with an insect vector that spread it, the stage was set for disaster in a great number of areas. For almost a decade, civic tree budgets were entirely consumed by the cost of removing dead and dying elms, and, in some cases, only

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recently have funds become available for replanting.

With these painful lessons to learn from, it is natural that most communities have taken the hint; most now have a list of six or more preferred species that are approved for street-tree planting. There is no reason for even a small town ever to repeat the mistakes of the past and use only one tree species on its streets. Safety lies in diversity, and a monoculture is very dangerous; a risk which should never again be taken.

Monoculture

There are aesthetic advantages to planting a given street to one species or clone. There is an impressive visual effect to be gained by a long avenue of identical trees. Some of the famous avenues of live oaks (*Quercus virginiana*) in Mobile, Alabama, are examples; another is the famous avenue of royal palms in Palm Beach, Florida.

This architectural effect is particularly important for long vistas leading up to important buildings, such as on college campuses and civic centers, and of course for avenues with ceremonial importance, such as Pennsylvania Avenue in Washington, D.C. To create this visual impact, planting a single species or, even better, a clone is necessary. But other varieties should be used on other streets or avenues so that, if an unanticipated disease should appear, the loss would not be disastrous.

Even for extremely formal avenue planting, a diversity of species is possible if the planting is composed of several parallel rows on each side of the street or grass sward composing the axis. The safety value of such a plan is particularly clear at Windsor in England. In this park, a most impressive vista or allee was planted more than two centuries ago. The grass strip was lined on each side by two parallel rows of trees, the inner rows composed of English elm and the outer pair of English oak.

After a slow buildup prior to 1945. Dutch elm disease has run wild in England, and the two inner rows of enormous old elms began to die, one after another. When the symmetry of the elm rows was irreparably destroyed, the scattered trees were removed, but the two outer rows of oaks remained; now, the vista is as impressive as ever. A replanting of the lost rows with lindens has been done to ensure the future.

Good examples of planting parallel rows of different species are to be seen in Canberra, Australia. This capital city was laid out at one time, and it abounds in impressive long avenue and park vistas, many lined with multiple rows of pin oak, sweet gum and various eucalyptus species. Because Australia has a number of serious root rot diseases, both native and introduced, the safety value of these diverse plantings, which still create impressive architectural effects, is obvious. If enough of one species is wiped out to spoil the integrity of the line, others remain to do the job.

In ordinary residential areas, there is not room enough for multiple rows of trees. There, one street can be planted to a single species or clone of tree, while the next can be devoted to another so that, while a uniformity of visual impact is created on each street, the town as a whole is not dependent upon any one tree or even only several trees for its shade and beauty.

Still other cities, such as parts of Richmond, Virginia, have planted several blocks of a street to one species, such as American beech, and then changed to another, such as sugar maple, for an additional stretch and then perhaps a third species further on. Particularly in the case of curved streets (and many in Richmond are curved) the change of street trees from a section of one species to that of another is not obvious unless one is particularly looking for it.

The most extreme form of diversity is the mixing of various species of trees on the same section of street. Such diversity is most common in the newer suburbs where there is no active shade tree commission, and the homeowners have planted whatever appealed to them. There may be some statutory control of a negative kind — i.e., undesirable high-maintenance trees, such as Siberian elm, Carolina poplar and silver maple, are prohibited. Or a list of permitted species may be adopted to require developers and homeowners to plant species taken from this list. Such random planting does achieve a desirable safety in numbers, but, in general, more pleasing landscape effects can be attained by advance planning and adherence to a general city street-tree

plan. Such a community-wide plan can not only enhance the beauty of individual streets, but also ensure a proper distribution of the species used by allotting a percentage of the total trees in the community to each species.

The filler tree concept

Examples of streets on which two species of trees have been alternated in the same rows are very rare. In general, the effect is not harmonious when two species that are similar but not identical are used, i.e., mixing sugar and Norway maples or water and willow oaks.

In contrast, there is much to be said for deliberately planting a street with two species in an orderly pattern if one of the species is smaller, shorter-lived or otherwise frankly included as a filler species with a temporary role to play on the street.

The use of temporary species for filler trees is not a new one. Around the turn of the century, it was tried around Boston and Philadelphia but then was abandoned. The problem was that rapid-growing and large species were used. When the time came to remove them in an orderly manner, the operation proved to be much more expensive than had been anticipated because of their size.

Furthermore, a "woodsman, spare that tree" attitude of a highly vocal segment of the population made orderly thinning politically impossible even if it had been possible financially. In consequence, the concept of filler-tree planting, as advocated in several early texts on arboriculture, fell into undeserved disrepute.

In reality, planting two or more tree species on a city street in an orderly predetermined pattern that anticipates later removals is an excellent system with many distinct advantages. The most consistent criticism of American shade-tree planting, especially in the newer suburbs, is that the trees are spaced too closely. The error is an easy one to make, as even a gardener planting out petunia seedlings soon discovers. Young trees as received from the nursery are so small in relation to their size at maturity that it is easy to miscalculate. Furthermore, every homeowner in a bleak new tract wants a tree in front of the house.

Major tree species (by general agreement, these are species that exceed 40 feet in height at maturity) should be planted at distances no less than 80 feet apart. An exception is thicket planting in the German style established along highways as a sound barrier. For this purpose, spacings of eight to 10 feet apart are not excessive. But even 3 inch diameter shade trees, when spaced initially at 80 foot distances, look very unimpressive, and the public is bound to wish for a better showing.

Here is where properly selected filler trees can fulfill every requirement. The ideal filler tree should have four characteristics. It should be easy to transplant; rapid-growing when young; 30 feet or less in height at maturity, and have showy flowers, good fall color or attractive bark color. By the use of filler planting, a new street can be relatively thickly planted at spaces of 20 to 40 feet apart, which will give an impressive showing when all the trees are young.

After a decade in place, the major trees that will comprise the final planting will rapidly outstrip the filler trees and begin to take on some of their final form. Whenever thinning is required, the small-statured filler species can be safely and very inexpensively removed. Because they are small even at maturity, public outrage at the removal of a large tree is avoided, and this problem need not arise. The final effect is a magnificent avenue of shade trees widely enough spaced so that each can reach its full size and spread, and "forest conditions" in lawns and front yards are avoided.

During the 10 to 20 years that the filler trees are in place, the street benefits from their showy flowers or other display. Some varieties of the smaller trees, though rapid-growing when young, mature early and complete their life cycle rapidly in comparison to the larger and slower-growing traditional shade tree species. They are therefore self-limiting in lifespan and fade out just when they would crowd the more permanent species.

Mixed plantings

The city of Angers, France has, for generations, been the center of the French nursery industry. It is natural that, located as it is in the midst of an enormous production of trees and shrubs, it should have a wealth of interesting and unusual street plantings. It has the only street planting in the world of *Populus lasiocarpa*, another unique one of *Robinia pseudoacacia fastigiata* and many

other fascinating rarities.

It is particularly interesting, however, for the extensive planting of streets of different tree species arranged in orderly patterns. One interesting combination alternates little-leaved lindens with crape myrtle (*Lagerstroemia indica*), the latter trained up as standards on six foot clear stems. The lindens bloom in June and the crape myrtles in August; in addition, they provide interesting bark patterns in the winter.

Another alternates London planes with purple-leaved plums (*Prunus cerasifera pissardi*) again trained up as high-headed standards. Here, it is the big planes that provide the bark color, while the smaller plums give both spring flowers and red summer foliage.

Another street once displayed alternate trees of southern magnolia (*M. grandiflora*) and Chinese windmill palm (*Trachycarpus fortunei*). An exceptionally severe winter in the late 1950's killed out the palms, but this loss left the magnolias at a proper spacing to develop the full spread and symmetry they show today. Not all of these plantings, such as the one that alternates Crimson King and variegated Norway maples, are acceptable to American tastes, but they do permit a latitude for experimentation with unusual clones and species. So long as one of the components is a tried and tested variety, the other one or two are not a serious loss if they do not prove satisfactory.

Such mixed street plantings are not confined to France alone. In Sweden, streets have been planted with alternating lindens and European white birch (*Betula alba* or *B. pendula*). In Charleston, S.C., crape myrtle has been used successfully in alternation with larger trees. In England, Kwanzan cherry and Lavalle hawthorn are frequently alternated in street planting, a combination that gives two colors and seasons of bloom as well as a fruit display in the fall. In several midwestern communities, flowering crab apples have been alternated with Norway maple and produced a good effect. A particularly colorful combination of large trees is provided by Autumn Purple ash (a clone of *Fraxinus americana*) and Marshall's Green ash (a clone of *Fraxinus pennsylvanica*). Both color up at the same time, the former a burgundy-red and the latter a clear yellow.

In areas planted to old shade trees beginning to senesce and die out from natural causes, interplanting with a different species is often a necessity. New streets can be planted with what are ecologically "pioneer" or early succession trees, for there is plenty of light, which they require. Trees such as London plane trees, honey locusts, flowering crab apple and goldenrain trees are excellent for such a situation but are poor choices for interplanting between large mature shade trees. Here, the light intensity is much reduced, and, because these species are intolerant of shade and easily lose their lower branches or produce thin, weak growth, they will give very poor results.

Fortunately, there are other species that are shade tolerant in their youth. Many of the larger ones are ecologically climax or late-succession trees in their native forests. In other words, where they grow, if forests are undisturbed by lumbering or forest fires, they finally make up the climax forest and maintain themselves indefinitely to the exclusion of shade-intolerant species that cannot reproduce themselves successfully in the resultant deep shade.

European and American beeches, sugar maple, flowering dogwood and hornbeam (*Carpinus*) can grow well in semishade and are therefore good trees to use for the gradual replacement of avenues of existing trees. The beeches and maples are, of course, major trees, tall at maturity, while the dogwood and hornbeams are minor trees. Wherever the gradual replacement of avenues of tall trees is a requirement, these climax species are the ones to use.

Trees of Climatic Zones

The following charts give some useful groups of tree species and clones for a number of climatic zones. The listings are not intended to be the only possible combinations; they merely suggest some good ones and serve as a stimulus to further thinking and experimentation. In most cases, trees that will give good results in a cold zone are also useful in warmer ones — i.e., trees suggested for Zone 3 are also widely and successfully planted in Zone 4, Zone 5, and Zone 6.

ZONE 3. Average Annual Minimum Temperatures (−35°F to −20°F)

Major trees. (40 feet and over at maturity)

Acer platanoides (Norway maple). Crimson King is not hardy in this zone. Other clones are fine.

Acer rubrum (red maple). Plant strains of northern origin only. Good for poorly drained sites.

Acer saccharum (sugar maple). Plant strains of northern origin only. Good for replanting where an old avenue is being renovated.

Fraxinus americana (white ash). Autumn Purple is an especially colorful clone.

Fraxinus pennsylvanica (green ash). Marshall's and Summit are fine clones.

Tilia cordata (little-leaved linden). The hardiest of all lindens. Greenspire is an exceptionally shapely clone.

Minor trees. (Less than 40 feet at maturity)

Acer ginnala (amur maple). Scarlet autumn color. Should be grown as single-trunked standards.

Betula pendula or *B. alba* (European birch). Use single-trunked standards. Subject to bark vandalism.

Elaeagnus angustifolia (Russian olive). Silver-gray foliage. Should be grown as single-trunked standards. Best in dry areas.

Malus baccata (Siberian crab apple). The hardiest species. Choose small-fruited clones. The flowers are very fragrant.

Sorbus aucuparia (European mountain ash). Large clusters of orange-red fruit.

ZONE 4. Average Annual Minimum Temperatures (−20°F to −10°F)

Major Trees

Acer rubrum 'October Glory® ' (October Glory® maple). Brilliant red autumn color in many different soil conditions. Red Sunset is also good.

Ginkgo biloba (ginkgo). Grows very well in city conditions. Plant male clones whenever available.

Gleditsia triacanthos (honeylocust). Shademaster® and Skyline are the best of the improved thornless and seedless clones.

Quercus borealis or *Q. rubra* (red oak). One of the fastest-growing oaks. Deep red fall color.

Quercus palustris (pin oak). Good for wet clay soil. The new clones without weeping lower limbs, such as Sovereign and Crownright are excellent for city street planting.

Sophora japonica (Japanese pagoda tree). Excellent in city conditions. Showy heads of white flowers in July and August. Regent is a superior clone.

Tilia tomentosa (silver linden). Rapid-growing and tolerant of pollution. Princeton is an excellent clone.

Minor trees

Amelanchier canadensis (shadblow serviceberry). Should be grown as single-trunked standards. Good flowers and fall color.

Cornus florida (flowering dogwood). Should be grown in high-branched, standard form.

Crataegus oxyacantha (English hawthorn). Crimson Cloud has an upright crown and brilliant red flowers.

Malus species (flowering crab apples). Vigorous growers with upswept branches are best for street use. Zumi, American Beauty and Van Eseltine are fine.

Prunus cerasifera 'Thundercloud' (Thundercloud plum). The richest color of all the purple-leaved plums. Pale pink flowers in spring.

Prunus sargenti (Sargent cherry). Deep pink flowers and orange fall color. The hardiest of all the Japanese cherries.

ZONE 5. Average Annual Minimum Temperatures (−10°F to −5°F)

Major trees

Liquidambar styraciflua (sweet gum). Plant only trees grown from seed or northern origin.

Platanus acerifolia (London plane tree). Unsurpassed for extreme urban conditions. Plant only the true original F_1 hybrid, seedlings vary enormously.

Quercus coccinea (scarlet oak). Glossy foliage turns glowing scarlet in the fall. Transplant with a ball of earth and trim severely when moved. Transplant in early spring only.

Tilia euchlora (Crimean linden). Glossy green foliage. Exceptionally tolerant of atmospheric pollution.

Zelkova serrata (Japanese zelkova). Dense, shapely tree of elmlike appearance. Village Green has the wine-glass shape of American elm but is resistant to Dutch elm disease.

Minor trees

Koelreuteria paniculata (goldenrain tree). Colorful young foliage and big trusses of yellow flowers in July. Grows especially well in the Midwest.

Prunus yedoensis (Yoshino cherry). Rapid-growing and wide-spreading. Masses of pale pink flowers.

Pyrus calleryana (Callery pear). Plant only the upright, thornless clones Bradford and Redspire. White flowers and fine autumn color. Unfortunately, a few towns seem to be confining their new shade tree planting to Callery Pears alone, always a risky procedure as past history has amply demonstrated.

Sorbus alnifolia (Korean mountain ash). Rounded crown of small, alderlike leaves. Showy flowers and berries. Redbird is a much-improved clone.

ZONE 6. Average Annual Minimum Temperatures (−5°F to 5°F)

Major trees

Acer macrophyllum (big-leaved maple). Plant only in its native Pacific Coast range. Clear yellow fall color.

Celtis laevigata (sugar hackberry). Tall tree with elmlike crown. Thrives in dry soil and city conditions. Free from witches-broom disease. Magnifica is an especially vigorous clone.

Quercus phellos (willow oak). Fine-textured foliage resembling willow leaves. Plant only trees grown from seed of the northern part of its range. Transplant in the spring only, never in the fall.

Quercus acutissima (sawtooth oak). Glossy leaves like chestnut foliage. No fall color. Easy to transplant; thrives in city locations.

Minor trees

Albizzia julibrissin (silk tree, mimosa). The hardier deep

pink variety, rosea, is the best to plant. Grows well in city conditions. Plant Tryon or Charlotte in the South, as they resist Mimosa wilt.

Ilex opaca (American holly). Slow-growing but makes a lovely small tree if trimmed up to standard form. Plant clones of northern origin in this zone.

Prunus blireiana (Blireiana plum). Reddish-purple foliage. Double pink flowers before the leaves expand; the showiest flowers of any plum.

Prunus serulata 'Shiro-Fugen' (ShiroFugen cherry). Vigorous-growing tree with a wide head. Masses of double white flowers constrasting beautifully with the coppery young leaves.

Preference for northern races of trees does not hold true throughout all zones, however. When the really warm ones are reached, the lack of sufficient cold in winter as well as excessive summer heat makes good northern trees perform very poorly or even die out entirely. For example, Betula pendula (alba) and Sorbus aucuparia are sickly and very short-lived from Zone 7 on south. In Zone 9 and Zone 10, only a very few of traditional northern shade trees are even worth considering, but an entirely new and very beautiful group of families and genera becomes available for use.

ZONE 7. Average Annual Minimum Temperatures (−5°F to 10°F)

Major trees

Cornus nuttalli (Pacific dogwood). Plant on the West Coast in its native range only. Slow-growing but ultimately a tall tree when mature.

Magnolia grandiflora (southern magnolia). A matchless flowering evergreen tree, equally at home on either coast. The selected clones are far superior to the general run of seedling-grown trees.

Quercus virginiana (live oak). This majestic tree requires plenty of space. It is much broader than tall at maturity.

Ulmus parvifolia sempervirens (evergreen Chinese elm). Flat-topped and wide-spreading with small evergreen leaves. Selected clonal strains are far superior to seedlings, which vary greatly.

Minor trees

Camellia japonica (common camellia). Rapid-growing clones with small flowers are best for avenue planting. Are good in semishade but poor in full sun. Require acid, well-drained soil. Suitable varieties include: Bernice Boddy (pink), Mathotiana Rubra (red) and Dr. Tinsley (white).

Eriobotrya japonica (loquat). Small, wide-spreading evergreen tree with long, dark green leaves. Yellow edible fruit.

Lagerstroemia indica (crape myrtle). The showiest deciduous flowering tree for the Midsouth. Deciduous but with colorful flaking bark. Red, white, lavender and pink varieties are available. Can be specifically grown in high-branched standard form.

Photinia serrulata (Chinese photinia). A very vigorous small tree with shiny evergreen foliage, showy white flowers and red berries in the fall. Requires special training to create standards for street use.

ZONE 8. Average Annual Minimum Temperatures (10°F to 20°F)

Major trees

Pinus canariensis (Canary pine). In hot climates, the southern pines makes good shade trees. This one is especially valued for its rapid growth and shiny needles.

Quercus chrysolepis (canyon live oak). Glossy evergreen leaves and broad-spreading head. Withstands dry and poor soils.

Quercus suber (cork oak). Small evergreen foliage and interesting corky bark. Withstands dry soil and intense summer heat.

Minor trees

Gordonia lasianthus (loblolly bay gordonia). Dense, narrow, small tree with shiny evergreen foliage and fragrant white flowers. Good in wet soil.

Heteromeles arbutifolia (toyon). A fine small tree, usually grows as a clump, with glossy evergreen leaves and scarlet berries.

Prunus campanulata (Taiwan cherry). The earliest-flowering cherry, with deep pink bell-shaped flowers and shiny foliage. Red strains are available.

ZONE 9. Average Annual Minimum Temperatures (20°F to 30°F)

Major Trees

Cinnamomum camphora (camphor tree). Tolerant of pollution, with dense, shiny foliage. Pest-free, slow-growing and long-lived.

Eucalyptus ficifolia (red-flowering eucalyptus). The showiest of the genus when in bloom. Slow-growing and dense, with evergreen foliage.

Eucalyptus globulus (blue eucalyptus). Rapid-growing tall tree with bluish foliage and pale gray bark.

Sapium sebiferum (Chinese tallow tree). Pest and disease-free; tolerant of many soil types. Lustrous poplarlike leaves turning red and orange in the fall.

Minor trees

Acacia baileyana (Cootamundra wattle). Graceful-spreading small tree, with fine-textured foliage and masses of fragrant yellow flowers in early spring.

Lagunaria patersoni (sugarplum tree). A shapely pyramidal tree with evergreen foliage and showy pink bell-shaped flowers. A good seaside tree.

Olea europaea (common olive). Attractive gray-green foliage. Exceptionally tolerant of heat and dry soil. Fruitless clones are now available.

Pistacia chinensis (Chinese pistache). Disease and pest-free; broader than tall. Compound leaves with showy red fall color.

Schinus terebinthifolius (Brazil pepper tree). Rounded evergreen tree with compound leaves. Spectacular display of red berries each winter.

ZONE 10. Average Annual Minimum Temperatures (30°F to 40°F)

Major trees

Ficus macrophylla (Moreton Bay fig). Enormous-spreading tree at maturity with large, glossy evergreen leaves.

Ficus retusa nitida (India laurel). Large tree, much broader than tall, with smooth gray bark and glossy evergreen foliage.

Grevillea robusta (silk oak grevillea). Evergreen, fernlike leaves, white underneath. Good upright crown for street tree use. Thrives in poor, sandy soil.

Phoenix canariensis (Canary Island date palm). Palms are not usually considered shade trees, but this one is an impressive long-lived avenue tree.

Roystonea regia (royal palm). Another fine avenue palm, tall and stately, with a smooth clean trunk.

Spathodea campanulata (African tulip tree). Tall, rounded tree with glossy, compound foliage. Bears terminal clusters of fiery-red flowers in late winter and spring.

Minor trees

Bauhinia variegate (orchard tree). Semievergreen, rounded, small tree bearing lavender flowers like orchids in early spring. Candida is a white form.

Cassia fistula (golden shower senna). Open-headed small tree, deciduous and bearing long pendant clusters of golden-yelow flowers in the spring.

Delonix regia (royal poinciana). The showiest of all flowering trees, bearing masses of orange-scarlet flowers. Flat-topped, wide-spreading and deciduous.

Jacaranda acutifolia (sharp-leaved jacaranda). An open, spreading tree with fernlike foliage and enormous trusses of lavender-blue flowers.

Nerium oleander (oleander). Usually grown as a shrub but can be trained up into a single trunk. Almost continually in bloom. There are many varieties with white, pink or red flowers.

Summary

The concept of mixed plantings is not a new one but rather an idea that has received less attention than it deserves. It is a method that emulates the diversity of natural forest communities in the temperate zones. It gives much greater opportunity to reduce the danger of serious inroads by insects or new diseases upon the urban tree population. Employing small-statured and shorter-lived species as one of the components on a given street makes it possible to please all the homeowners by planting a tree on every lot. At the same time, it is also possible to plant the slower-growing and most permanent species at proper spacing for optimum development. Finally, it encourages experimenting with new species or clones, experiments from which valuable experience can be gained regarding their value as street trees for that particular area. If the trial is successful, much will have been gained. If it was not, no serious loss will have resulted. These odds make mixed planting a very good risk.

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ABSTRACT

Smith, E.M. & C.H. Gilliam. 1980. **Soil fertility practices are vital for growing healthy landscape plants.** Am. Nurseryman 151(3): 15, 78-82.

Frequently assessing plant growth, soil, and foliar analyses are a landscaper's keys to developing the most effective fertilizer program for a plant. Using the results from soil and foliar reports and studying plant growth enable landscapers to optimize plant growth without under or over fertilizing. The purpose of fertilizing landscape plants the first year or two after transplanting is to increase plant height, width, and caliper. However, once plants are established, the function of fertilizing is to maintain good plant growth and health but not necessarily to promote growth. Research in Ohio has shown that applying about three pounds of nitrogen, the mineral element most responsible for vegetative growth, per 1,000 square feet per year or six pounds every other year properly maintains the health of woody plants in most established landscapes. If foliar color, annual growth or general vigor is not normal, increase the rate to five or six pounds of nitrogen per 1,000 square feet per year. If soil or foliar tests are available, follow their recommendations; otherwise the rates suggested above are a good guide.