THE FOREST AND THE STREET: A COMPARISON OF TREE IMPROVEMENT IN FORESTRY AND HORTICULTURE

by

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Some 20 years ago research in shade-tree improvement was in a stage of development comparable to that of forest-tree improvement. Only a handful of qualified scientists were engaged in research designed to utilize genetic variability of trees as a means of the selection and breeding of superior timber ornamental types. During this period, Dr. Ernst J. Schreiner, one of the earliest forest geneticists, published two articles outlining the shade-tree problem and advocating the establishment of a Federal Shade Tree Service. As we are well aware, there is presently no such Shade Tree Service. Furthermore, the ensuing years have seen a rapid development of forest-tree genetic and improvement while research on shade and ornamental trees has remained relatively static.

It is not the purpose of this paper to list or discuss the probable reasons for the past lack of emphasis on shade-tree improvement, but rather to emphasize the current upsurge of interest in shade-tree research and to place such research in proper perspective in relation to improvement projects with forest trees.

The resurgence of concern for shade and ornamental trees has resulted from an appreciation of the special role of trees in "humanizing" our rapidly evolving urban and suburban environments. New projects on a variety of problems have been undertaken by the Federal Government, State agencies, universities, and private organizations. Within the U.S. Department of Agriculture, research on trees is done by both the Agricultural Research Service and the Forest Service. In most instances, the responsibilities of the two Services have been clear-cut, e.g. fruit and nut trees (ARS)—forest trees (FS). However, where both native and exotic forest and ornamental trees are utilized for beautification or environmental improvement, the delegation of research responsibility has been more difficult. Representatives of both Services, meeting together, have recently drawn up guidelines on this subject, and future coordination and cooperation will allow for maximum utilization of available research resources.

For the present, let us examine some of the similarities and differences of tree-improvement programs in forestry and horticulture.

GOALS OF BREEDING AND SELECTION

Forest-tree improvement is geared to the development of trees having:

1. Rapid growth rate
2. Desirable form and tree quality
3. Desirable wood characteristics
4. Pest resistance

Growth rate is also important .in shade-tree research and frequently emphasis has been placed on fast-growing trees. It is well-recognized, however, that the ultimate size of the tree is the major growth factor that must be considered. Furthermore, the shape of the tree must be taken into account. The tree form and quality characteristics sought by forest-tree breeders represent a small portion of the spectrum of tree shapes used in amenity planting. Urban planting areas vary considerably in their capacity to provide appropriate space and desirable setting for trees of different sizes and growth habit. A narrow city street with buildings close to the sidewalk may be the ideal setting of narrow-crowned, columnar cultivars that would be out of place on a broad avenue or parkway. Likewise the tall and spreading types should not be planted where low, overhead wires are a problem. "The right tree in the right place" is a maxim for effective shade tree planting.

It should be emphasized that the goals of shade tree research are to provide trees with a variety of growth rates and growth forms for the multiplicity of planting sites and settings of the urban environment. In addition, it is important to note that the various growth types can be found or developed in a number of genera and species. All columnar or fastigiate trees need not be of the same species or cultivar. The genetic variability that has allowed for the selection of unusual types in one genus or species may allow similar types to be selected or bred in any genus otherwise suited to city planting.

Wood quality, as it pertains to the value of timber, is not an important factor in shade-tree improvement. The principal wood-related character in shade trees is the ability to withstand wind and ice storms without undue damage. Storm-resistance is partly a function of the branching angle or forking characteristics of a tree, and these factors are well understood. There must be, however, certain elements of a physical nature that render some species or cultivars more resistant to breakage. An appreciation of possible improvements in storm-resistance should be maintained in shade tree research.

Resistance to disease and insect pests is, after growth characteristics, the most important goal of shade-tree research. While this subject is discussed below under "Pest Problems" some mention should be made at this time regarding the importance of pest-resistant trees. Great sums of money and much research effort has produced an arsenal of chemicals that can be used to control virtually all the important pests of shade trees. However, few of these chemicals are so selective that only a specific pest is killed or controlled. The undesirable toxic side effects of many chemical sprays have recently been emphasized in the popular literature, and while overstated in some instances, these effects cannot be dismissed lightly. Furthermore, an effective chemical spray program is expensive. Chemical control of the Dutch elm disease vector is an annual expense that many municipal parks departments and some communities simply cannot afford. While it may be desirable to protect mature trees in our cities through chemical control, the planting of new pest-susceptible trees should not add to the burden.

In the long run, the development of resistant trees will provide the most efficient means of pest control, from both the biological and economic points of view. The utilization of different biological sources of resistance coupled with enlightened planting practices should serve to minimize the maintenance budget and guard against the possibilities of pest variability.

Recent advances in pest control through biological (parasites, predators, and diseases) and mutagenic (radiation sterility) agents have been most encouraging. The combination of natural resistance and "natural" control measures offer still greater opportunities for the elimination of potentially dangerous chemicals from our environment.

There are also other factors that must be considered in working with shade trees that are beyond the goals of forest-tree improvement. General "cleaniness" of the tree, including lack of fruit, is frequently a desirable characteristic. Attractive seasonal leaf coloration is also to be desired. The root systems of shade trees should not be such as to interfere with underground pipelines, nor should they be so close to the surface as to disrupt sidewalks. Ease of vegetative propagation is necessary to achieve production and wide distribution of improved cultivars. Ease of maintenance, including pruning, may also be an important consideration.

SPECIES SELECTION

One of the most obvious differences between forest and shade trees is that forests occur in nature, whereas shade trees must generally be planted. Reforestation and aforestation research in this country has emphasized the use of native American species planted in environments similar to those of the species natural range. In general, trials of true foreign exotic species have ranged from barely satisfactory to disastrous. Furthermore, although conifer and hardwood types occupy about equal areas throughout the United States, 80 percent of the sawtimber volume is in conifers with five species groups constituting 67 percent of the total. The emphasis on conifers in forest-tree improvement research is a reflection of this situation.

On the other hand, the vast majority of the species used in shade tree and urban planting are hardwood (broad-leaved, deciduous) types and include both native and exotic species. Among the native trees, the genera most utilized in shade tree planting are those that have a low unit value as components of the forest (e.g. *Ulmus, Platanus).* Native hardwood genera containing species having a high unit value in the forest (e.g. *Betula, Juglans)* have limited potential as shade trees. In recent years, non-native types such as the London plane *(Platanus* x *acerifolia)* and Norway maple *(Ater platanoides)* have predominated in shade tree planting.

It is restrictive, however, to make divisions between shade-tree and forest-tree research based solely on the geographic origin of the plants involved. For maximum improvement, germ plasm from a wide variety of biological and geographic sources must be utilized. As one eminent forest geneticist has repeatedly pointed out, the genus, rather than the species, constitutes the genetic base of improvement. When the use characteristics (e.g. wood density, fiber length, etc.) of a tree are sufficiently satisfactory in a given adaptable species, that species should occupy the focal point of improvement work. Other members of the genus, with which the principal species can be crossed, may be utilized in the improvement program insofar as they may contribute to other desirable attributes, such as pest resistance. When the use characteristics of a tree are sufficiently broad, such as the capacity to provide shade and esthetic value throughout the year under difficult environmental conditions, the "improvement" potential may even extend outside generic lines to include species of similar growth habit and characteristics.

The improvement of shade trees must involve both native and non-native species and genera in order to achieve the diversity of size, shape, color, pattern, and texture required in the beautification of our homesites, streets, and parkways.

PRODUCTION OF PLANTING STOCK

Coniferous planting stock for reforestation is easily grown in large amounts from seed at nurseries operated by Federal, State, and private agencies. The facilities developed for run-of-the-woods stock is equally adaptable to genetically improved stock and only in rare instances are the seedlings more than 3 years old when outplanted. Hardwoods for forest planting are also generally outplanted at 1 to 3 years of age. With the current federal-state and university-industry cooperation in forest-tree improvement the consumer of the improved trees is also either the producer or a cooperator in the production of nursery stock. The short nursery rotation time not only enables the consumer to plan in advance for the disposition of the planting stock but also allows for adjustment or modification of plans when circumstances warrant. Because of the vast acreage of potential forest land in need of planting, it is not surprising that most forest-tree seedlings are used for their intended purpose.

The major consumers of shade and ornamental trees are municipalities and government agencies, land developers, or private individuals who desire trees to beautify the landscape in their city, around their buildings, or on their home grounds. Of these consumers, the municipality is the best able to own and operate a nursery for the production of trees for its own use. However, shade-tree production is so costly that few cities have ventured into the nursery business and must, therefore, purchase their trees from commercial nurseries.

The production of shade-tree planting stock in the United States is largely in the hands of private, commercial nurseries. Many of these nurseries are small and some are marginal operations. Although the current demand for shade trees is at a high point, the general fluctuation in the market has argued against carrying large inventories. While it is true that trees that do not sell in any given year might still be marketed 2 or '3 years later, experience has shown that the "clear-cutting" of older plant material is frequently a necessary operation.

In general, it may take from 5 to 10 years to produce hardwood shade trees of desirable landscape size. Home owners may prefer the smaller and cheaper 8-to-10 foot specimens while street plantings usually require larger sizes. Sometimes a particular planting job may demand trees up to 10 inches DBH and costing several hundred dollars per tree. In such cases, a nursery may thus be able to market its previously unsold trees and recover much of its investment in land and time.

The nursery's investment in time, space, and labor is, however, relatively the same for seedling plants as for selected and vegetatively propagated material. Thus, even with the "protection" of plant patents, there is little incentive for the nursery to undertake selection or breeding programs to improve the quality of their trees. Fortunately, a few far-sighted individuals and organizations have maintained high selection standards over the years, and produce tested and reliable clones of a number of the more important species and genera. Still, profit is essential to any business enterprise, and costly research will rate far down on the nursery's scale of priority.

There is yet a third party to the shade-tree business, and that is the tree planter. He does not produce the stock nor grow the tree—he merely plants them. "Merely" may be a poor choice of words, since even the best tree cannot survive a poor planting job. The tree planter is the middle-man between the city and the nursery. Sometimes a contract may call for a certain number of trees of a particular species of maple and the tree planter may be fortunate enough to find well-grown trees of the correct sizes. At other times substitutions on species or clone and size categories must be made and frequently there must be compromises on tree quality. Thus the planting may be less than desirable.

What does all this discussion mean? Simply that while the consumer (city), the producer (nursery), and the planter may all recognize the need for improved shade and ornamental trees, none is sufficiently in control of the whole tree-growing operation to maintain quality control throughout all its phases. It is to be hoped that the same degree of research interest and cooperative spirit that has enabled forest-tree improvement to make such rapid strides will also prevail for the beautification and improvement of the environment we live in.

PLANTING SITES AND ENVIRONMENT

While forest trees are generally planted on favorable sites, shade trees are usually planted where extremely adverse conditions of site and environment prevail.

The soil environment of city trees probably has been one of the least appreciated factors in shade-tree research. In the city, tree root growth is restricted by poor soil aeration resulting from soil compaction or impervious soil coverings of asphalt or concrete. Poor aeration also aggravates nutrient deficiencies and water stress. High concentrations of salts resulting from winter salting of roadways also have deleterious effects on root growth. Formerly, leaks in lines carrying artificially produced gas were a serious problem. Natural gas, which is becoming more widespread in use, is apparently non-toxic to plant roots' 'but may contribute to the removal of oxygen from the root environment. In addition there are subterranean wires, steam pipes, and other accountrements of civilization that further influence the environment beneath the ground.

Above ground, the city contributes its own peculiar interferences to optimum tree growth. Various air pollutants produced by industry or automobile exhausts may frequently damage the foliage of a tree or weaken its resistance to pests and climatic changes. The presence of overhead utility wires, while not constituting any direct hindrance to tree growth, does require costly tree pruning that certainly alters esthetic tree shape and may cause other problems. The reflected heat from streets and buildings may frequently result in temperatures high enough to cause tree injury.

In short, the sites for forest and shade trees are widely different. In both forest-tree and shade-tree improvement an effort should be made to select trees adaptable to site conditions. Testing of selected trees for forest use merely entails the establishment of test plantations on the desired site. But what about street trees? The performance of a tree, growing in a plantation in a rural or suburban field where the more important factors contributing to optimum growth and development have been provided for, may not be a true measure of the tree's potential when grown in a roadside planting. However, large-scale, statistically adequate testing with a diversity of biological material along city streets is not practical in the urban environment. Methods and means of adequate testing for urban environments, as well as for the improvement of those environments, must be developed if we are to achieve maximum effectiveness in selecting or creating better shade trees.

PEST PROBLEMS

Insect and disease pests in the forest may cause the death or reduce growth and value of scattered trees or, in times of epidemic, vast areas of timber. Except under epidemic conditions, this normal attrition is not considered to be a major problem, since, in effect, it allows the survival of the fittest and may serve as a natural thinning and selection.

In shade trees, on the other hand, pest problems are of paramount importance. The city tree is already growing under environment stress and insects or pathogens that may be of minor importance in the forest may be quite destructive in the city. The clonal monocultures that prevail in some areas provide not only maximum uniformity in desirable characteristics but also uniformity in undesirable attributes, including susceptibility to pests. Furthermore, minor pests in the forest that may merely detract from the appearance of a tree (e.g. leaf beetles, leaf spots, powdery mildews) are of considerable importance on shade trees.

It is true that methods of chemical and biological control have been developed for many of our most destructive pests, but many problems remain. The development of pest-resistant trees is necessary in both forest-tree and shade-tree improvement work, but biological, economic, and esthetic considerations should serve to maximize their importance in the city.

One of the most important immediate areas of pest-resistance research that must be undertaken in the near future is the search for resistance to soil-borne fungi. That such research can be successful is evidenced by the *Fusarium* wilt-resistant clones of *Albizzia julibrissin* (mimosa) that have been found by U.S.D.A. scientists. Other diseases that should be investigated are Verticillium wilt of maples and other species, and *Armillaria* root rot of a great number of trees.

A major point of divergence between forestry and horticultural goals is that, for horticultural purposes, a disease-resistant type need not be of outstanding merit in aboveground growth characteristics to warrant its immediate use. The common utilization of rooting, budding, and grafting in the production of horticultural stock allows the creation of improved trees in which rootstock and scion have been selected for different attributes. In fact, disease-resistant rootstocks do not always have to be of the same species, or even the same genus, as the scion cultivar. It should be pointed out, however, that some apparently successful interspecific grafts have given poor results in later years.

COSTS AND RETURNS

Forestry is a business. The wise and far-reaching application of the multiple-use concept by the U.S. Forest Service should not obscure the fact that owners of forest land expect to make a profit from their trees. The costs of producing and planting conifer stock, coupled with the general low maintenance costs, are such that profits are usually realized. An improvement in growth rate, wood quality, or pest resistance achieved by scientific research can thus be measured on a monetary basis.

On the other hand, the major growers of shade trees are municipalities or individuals who only expect to achieve esthetic values from tree planting. A young, 7-to-9-year-old shade tree purchased for urban planting may cost more than a 80-year-old individual of the same species is worth in the forest. The costs of planting, pruning, and spraying the shade tree throughout its life add to the investment in the tree. When the tree finally dies, seldom of old age, the cost of removal may exceed all other expenditures involved in growing the tree.

What is a shade tree worth? Valuation formulas have been devised by various groups for assessment purposes and legal situations, but are they valid? The simple truth is that the value of a shade tree cannot be reliably determined.

How then, can we measure the value of shade-tree improvement? One way is to measure not the profits but the reduction in costs. Proper growth should reduce pruning costs; pest resistance should reduce spraying costs; and site adaptability should reduce replacement costs. Furthermore, the costs of removal can be delayed or spread over a greater period of time.

When, in addition to a reduction in costs, improved shade trees provide shade and beauty throughout the years, it can be said that we have profited by their development.

HOW CAN HORTICULTURE BENEFIT FORESTRY ?

Horticulture has already been of much benefit to forestry and forest-tree improvement. Most of the early plant exploration and importation was carried out by botanists and horticulturists. The collection of exotic species maintained in arboretums and botanical gardens have served foresters as a major source of material for the initial evaluation of the potential of such species and for interspecific hybridization studies.

With the abundance of native adaptable species in every area of this country, the introduction of exotics for direct use has played a small part in the overall forestry program. In other areas of the world, the arboretum introductions have been more important. For instance, the potential of Monterey pine as a forest tree in Australia was recognized after being planted at the Melbourne Botanic Garden in 1857.

However, forest geneticists have now taken the lead in introducing exotic foreign trees. They have recognized the genetic limitations imposed by single introductions and have sampled the ranges of many species to obtain maximum genetic diversity. Through proper management, the plantations established with these introductions may be maintained as gene "banks" that can be drawn on far into the future.

Few, if any, trees selected or developed for shade or ornamental purposes will find direct use in forestry for timber production. In many instances the emphasis on different species and use characteristics in the research programs will be an obvious limitation. As forestry becomes more "urban," however, the trees produced by horticultural tree improvement programs may well be an integral part of the forestry picture. Shade-tree improvement programs can definitely benefit forestry by supplying tested, pest-resistant trees, or trees with proven adaptability to difficult sites and environments.

HOW CAN FORESTRY BENEFIT HORTICULTURE ?

There used to be, and perhaps still is, an opinion among forest geneticists that many of the "culls" resulting from their research programs might have "horticultural value". Although this notion was expressed at least partially in jest, the idea prevailed that horticulture eagerly awaited the introduction of any new and "oddball" plant. Not so! Horticulture is not in dire need of any more dwarf, contorted, prostrate, weeping, yellow-leaved, variegated, or otherwise atypical trees. To be sure, some cultivars of the above types might find a place in ornamental planting but these cannot be considered as major objectives.

The improvement of shade and ornamental trees does require individuals with good growth habit, pest resistance, and tolerance to various stress factors of the urban environment. In short, horticulture can utilize those trees that are among the best products of forest-tree improvement research.

Research cooperation is the key to maximum benefits to both forestry and horticulture. It is expected that the two-way flow of information and material between horticultural and forestry research will promote the development of truly superior trees, for whatever use they are intended.

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