A Guide to Selecting a Strong and Healthy Young Tree

In the wild, the basic structural form of a tree is logically related to the various stresses of its lifelong growing conditions: stem, leafy branches and roots are molded to forms which will best suit the tree's performance in a particular landscape, whether to reach up high for a woodland's diminished sunlight, or to spread out wide into the abundant sunlight and space of an open field.

In a nursery, the basic structural form of a tree is artificially molded by a set of growing practices. Its strength and health and beauty are largely a product of the grower's sensitivity and expertise: how wide he makes his rows and spaces his plants, how frequently he root-prunes or transplants them, how sensitively he trains them, how they are stored and marketed. His techniques may produce a tree far more suited to be grown as a specimen in the average landscape than a tree one would be likely to find in the wild; or they may inadvertently produce a tree which is a structural failure.

The long-range significance of some growing techniques has not been well understood. For instance, research at the University of California at Davis in recent years has demonstrated that the natural capacity of young seedling trees to support themselves even in a high wind can be undermined by severely crowded conditions, or the drastic pruning and staking practiced by some growers. Modifications of the tree's canopy and trunk structure may create an individual which is actually unable to support itself upright when moved out into the landscape (6, 7). Similarly, modifications of a tree's root system through container line production may create permanent structural defects rarely found out in the wild.

Such deformities as these underscore why trees are such a particularly vulnerable form of merchandise; not primarily because they may not have survived poor handling or growing conditions (living things are remarkably adept at finding ways
A tree may be inadvertently modified by growing practices in such a way that it actually can no longer support itself upright, such as this young Tupelo.
to adjust to the most adverse conditions), but because their structural quality and vigor may have been critically diminished through the struggle to survive. And, unfortunately, this kind of damage is not always immediately perceptible.

It is of particular significance with trees, over smaller and shorter-lived plant material, because what initially may be considered a minor structural handicap may become a major structural flaw in time. As a tree matures, the sheer massiveness of its upright bulk generates enormous stresses on every part of its framework. To hold together, and meet the force of environmental stresses successfully, this framework must be strong and healthy.

The stem. According to research at the University of California at Davis, trunks tapering uniformly from base to tip can withstand greater stress from wind and vandals than trunks with little or no taper. While a tapered trunk tends to bend uniformly along its entire length, a trunk with little or no taper bends from the base and is more susceptible to deformation or breakage. Crowding or rigidly staking a tree tends to suppress the normal outward growth of its trunk and the normal trunk taper, while increasing its height (4, 5, 6, 7).

The relationship between the trunk diameter (or “caliper”)* and height of a tree is one of the most visible indications of the environment it has come from and the quality of a grower’s cultural practices. Trees grown in crowded rows bear the same features as woodland trees: trunks are tall and narrow, branching is concentrated up high towards the only available source of light with lower branches dead or dying from lack of light. Trees which have grown particularly fast from being over-watered and over-fertilized also tend to be taller and lankier than average, but branching is more widely and evenly distributed along the trunk. Those which have grown slowly due to poor soil conditions, girdling roots, or an extremely exposed site tend to have the form characteristic of dwarfed plants: branches and trunk are short and stout, branching is concentrated densely along the stem.

While caliper or height is usually the governing measurement for categorizing the size of a tree, the relationship between height and caliper is so greatly variable that referring to stock

* Caliper of trunk is measured 6 inches above ground level up to, and including, 4-inch caliper size; 12 inches above ground for larger sizes.
solely by one characteristic or the other gives an unreliable indication of the plant's actual size and age.

Accordingly, the American Association of Nurserymen has developed standards useful for indicating a "normal" relationship between key characteristics of several different types of trees. For instance, shade trees are expected to have a rather broad, but definite correlation between height and caliper. Smaller growing trees are expected to have a correlation between number of branches and height, or among height, caliper and number of branches (see Tables I-III).

The canopy. Branching is characteristic of a particular kind of tree and a given site. But in almost all cases the growing tip of a tree should be limited to one dominant ascending shoot (or "leader"), because trees with multiple leaders lose their directed upward growth. Double leaders are apt to have a narrow angle of attachment to the trunk, and as branches form on one side only of each leader and greater pressure is exerted on this weak point of attachment, the tree may eventually split in two.

The proper height above ground of the first permanent branches depends largely on personal taste, the type of tree, and the landscape use it will be put to; and may vary from only a few inches to many feet. But note that the height of a branch will always stay fixed at exactly the same distance from the ground (except for its thickening); in other words, branches do not grow up as the trunk elongates.

There has been a tendency to train a young tree's branches disproportionately high up for its size, particularly in the case of street trees. If a high branching specimen is required, it should be trained gradually. At least some temporary branches should be left on the stem as these branches will both protect and nourish the young trunk, contributing measurably to its caliper growth and taper.

As a result of their findings at Davis, Richard W. Harris and Andrew T. Leiser recommend that one-half or more of the foliage or one-year-old wood be left on the lower two-thirds of the trunk, and half or less on the upper third of the trunk. Besides contributing to the proper growth of the trunk, this distribution will center the wind load acting on a tree at a mechanically desirable point at about two-thirds its total height (6).

If the tree is old enough to have formed permanent branches, their vertical and radial distribution up the trunk should be carefully noted. The major scaffold branches of a tree are best
Overcrowding has produced extreme attenuation of form in 18 ft. tall, 1¾ in. caliper Honeylocusts growing a scant 2½ ft. apart in the row. Note concentration of canopy towards upper one-third of trunk, narrow stem girth in relation to height, dying lower branches. A height of about 10 to 12 ft. would be normal for the caliper of these trees.
distributed symmetrically up the trunk in a configuration that avoids competition for nutrients and light. At least 8 inches and preferably 1½ to 2 feet should be allowed vertically between major scaffold branches; many mature branches lie 4 to 12 feet apart vertically. As a tree matures, closely spaced branches may break more easily than those with wide spacing because close spacing encourages long thin branches to develop with little structural strength (4).

All permanent branches should be attached widely to the trunk, as narrow angles of attachment are weaker and are apt to split with increasing stress as the tree grows.

If a tree has lost its leader, undesirable whorls of branches shortly spaced apart may be formed. Branches lying directly over each other are considered undesirable because they must compete for nutrients and water, and the lower branch is shaded. Two or more vigorous branches at or near the same level of trunk are apt to suppress the leader and limbs growing above. Crossing branches, or branches growing vigorously upright in an otherwise horizontally branching tree will have to be removed to avoid interference.

Roots. A particularly vital mechanical and nutritional inter-
relationship exists between the roots and aerial portions of a
tree. But an imbalance between roots and canopy is not un-
common in greenhouse and container production when plants
are subjected to an overly intense feeding and watering pro-
gram which tends to encourage top growth over root growth,
and produces a small root system incapable of supporting the
canopy and trunk in a more demanding environment without
commensurate maintenance (6).

An even more drastic disruption of the nutritional and me-
chanical balance between aerial parts and roots occurs each
time a tree is transplanted. When roots are cut in transplanting
not only the physical stability of the tree is affected, since the
ratio of above to below ground parts is thrown off, but also its
capacity to absorb enough water and minerals from the soil to
maintain its disproportionately large aerial structure.

How severe this imbalance is depends on what proportion of
the root system remains, how rapidly it can regenerate, and
the type of environment in which it is planted. While the
growth characteristics of root systems vary by species, and some
types of trees are innately more difficult to move than others

Right: The two balls in the foreground are “soft” or “homemade” balls,
dug up bare root and simply wrapped loosely in burlap and soil after-
wards; the root ball lying behind them has the characteristics of a “hard”
ball, dug and carefully packaged in burlap to keep the entire ball of
roots and soil intact. Root balls should never be left exposed like this to
possible injury from heat and drought.
Above: During storage, containers should be as well mulched as root balls to prevent damage to root systems from temperature fluctuations and drought. Note well mulched stock stored to the right and left.
New roots have penetrated lower one-third of burlap on a Cut-leaf Beech apparently over-wintered above ground in a heavy mulch. The absence of new roots on the upper two-thirds of the ball is probably due to root injury from alternate freezing and thawing.

(such as Pawpaw, Hickory, Dove Tree, Walnut, Tupelo, Sassafras, White and Scarlet Oaks), growing practices can exercise a considerable effect on the ease of transplanting.

The development of a root system is influenced by the entire soil environment (soil texture, availability of water and nutrients, soil depth, and competition). A more compact root system is apt to be formed in deep organically rich soil than in sandy soil.

Root systems are also directly and positively modified by the nursery practice of root pruning: an important element of nursery training which should occur every few years as it tends to artificially consolidate a rangy system by encouraging side branching. Trees grown in the wild are particularly difficult
Poorly stored Hawthorns have lost most of their foliage by mid-summer. Burlap has completely disintegrated on the two root balls in the foreground, and the balls are crumbling apart. The other balls are wrapped in plastic which is tightly bound around the base of the trunks with wire — presumably to seal in the moisture and create a “carefree” maintenance system.
to transplant because their roots have never been shortened through pruning.

Trees are sold with their roots in containers, or balls of soil wrapped in burlap, or completely bare. Each method has its advantages and disadvantages. Bare root stock and containerized plants are much cheaper than field grown trees which have been carefully balled and burlapped. But trees moved bare root are affected most severely by transplanting since many small feeding roots are damaged when the soil is disturbed, and the root system is more vulnerable to mechanical and climatic damage while being stored and shipped. Normally only trees such as maples, ashes, and honeylocusts, which have demonstrated their relative speed of recovery, are sold bare root; and they are available only in small sizes, during the dormant periods of fall and early spring.

Containerized stock is affected least by the transplanting process; the entire root system can be easily transferred and few of even the small roots are apt to be lost in the process. Nevertheless, containerized stock is sometimes subject to critical root defects, and should be examined closely for damage (see section on Root damage).

Clearly, a tree moved with an intact ball of earth around its roots ("balled and burlapped" or "B&B") will retain more of its small feeding roots than a tree moved bare root, which is why trees reputed to be difficult to move are always transplanted B&B even in small sizes. or grown in containers. In addition, the buffer provided by the soil around the root system tends to protect roots of both containerized and B&B stock while being stored or shipped.

There are several techniques to balling and burlapping a tree's roots; but due to the increasing expense of handling stock, recent practices are tending to become more expedient and less expert. The best method produces a completely intact ball of earth and roots, which is packaged so expertly it is unlikely to shift or come apart during transport and replanting. In recent years nurseries have tended towards the "soft" or "homemade" ball for all but the largest or most difficult material. This alternative is really just a bare root tree wrapped in soil and burlap. Since the original ball of soil has not been retained intact, one might well question whether a homemade ball accomplishes much over the bare root method, aside from buffering the root system a bit from mechanical or climatic injury.
Signs of branch die-back from poor storage.
The major structural framework of this young Dogwood is poor. The kink in the trunk may be left from the point where a competing second leader has been removed later than desirable, as it has already substantially affected the form of both trunk and canopy. Under stress, the weak V-shaped joint where the leader divides into two main branches may split right down the middle.
Another Dogwood with a basic structural flaw. Instead of branching outward from the stem, one of the three major branches of this specimen is growing in against another and will have to be removed — leaving a large hole along one side of tree’s silhouette.
The American Association of Nurserymen also provides minimal standards governing the spread of roots in bare root nursery grown shade trees. For instance, a tree of 2 to 2½-inch caliper, approximately 12 to 14 feet high, would be expected to have a minimum root spread of about 28 inches (see Table V).

The amount of stress on roots to provide water for the above ground structure varies according to weather conditions and the relative dormancy of the plant. The hotter the weather and the more fully leafed out the plant, the more water normally passing through its system from roots to leaves. This is why plantsmen prefer to move field grown material in the cool damp periods of early spring and fall when deciduous stock is dormant; however, it is possible to move just about any kind of tree any time of the year if it is done expertly and with a large enough root ball.

To reduce the imbalance between above ground and below ground parts, a newly transplanted tree is usually pruned. If it has been moved bare root, the tree is normally pruned quite severely, with up to a third of its branches removed. While necessary if a tree has been moved roughly, this method of compensation has important disadvantages: the tree may lose several years' past growth in a heavy pruning; pruning the canopy in turn reduces the tree's capacity to produce and store food needed not only for sustenance but also for its new growth; and, of course, balancing the canopy to the roots will in no way diminish the dimensions of the trunk which will remain out of proportion to both of them. If greatly disproportionate, the trunk may even consume most of the food produced by the tree simply to sustain its bulk.

Root damage. Growing practices can be responsible for a series of root deformities which may seriously handicap a tree for life, or even cause its death if left uncorrected (6). Kinked, twisted or circling roots are most commonly found in containerized stock, but also may be observed out in the field if the stock has been raised in containers at some point. These root defects are easily corrected by pruning while the roots are young; but as a tree matures, one may do as much damage by attempting to correct them as by leaving the tree alone.

Improper storage of tree stock also may be responsible for
extensive damage to the root system. When roots are raised out of the ground, whether balled and burlapped, containerized or bare root, they become extremely vulnerable to temperature fluctuations, drought, and mechanical injury. Roots on stock stored out of the ground in cold weather may be entirely or partially killed by alternate freezing and thawing. In storage the entire root system should be kept well covered with a thick layer of mulch, and watered regularly.
Two Silver Maples toppled over by the wind. These are actually balled and burlapped trees which were replanted in containers to keep the root systems intact during prolonged storage. When replanted, burlap should have been pulled back from the upper one-third of the ball.

The American Association of Nurserymen provides standards for the relationship between tree caliper and a minimal ball diameter (in the case of shade trees) and between tree height and a minimal ball diameter (in the case of smaller growing trees). For instance, shade trees of approximately 2 to 2½-inch caliper are expected to have a minimal ball diameter of about 2 feet; smaller types of trees of about 6 to 7 feet would be expected to have a minimal ball diameter of about 1½ feet (see Table IV). The American Association of Nurserymen figures are applicable only to stock which has been grown under favorable conditions and which has been properly root pruned. Plants with a coarse or widespread root system, or those moved out of season, would require a larger ball.
Defective bark on a Dogwood.
A confused whorl of branches with no dominant growing point characterizes the growth response of a tree which has lost its main leader. The Norway Maple on the right, the same age and caliper as that on the left, but with an intact single leader, is a foot or so taller and has the directed upward growth we associate with most shade trees. Note also the vertical distribution of the canopy on these two trees: both have been trained higher than desirable for their present height, with the canopy concentrated along the upper one-third to one-fourth of the trunk. This is not atypical of most shade trees available in the trade, but for the sake of structural strength and nourishment of the trunk it would be preferable to raise the crown more gradually.

A group of young Norway Maples with branching occurring in undesirable whorls. This is a common growth response when the main leader has been pinched back to induce branching.
Indications of health and vigor. A specimen’s vigor is indicated by the plumpness of its buds; the size, color and shape of its leaves; the length of last year’s growth, as indicated by the length between terminal bud scars; and the rate of callousing over small wounds.

Any signs of branch die-back, or leaf-fall and discoloration should be taken as ample indication of poor health and vigor. Bark should be light and smooth; bark and leaves should be free from all signs of pests and diseases. Young roots should be light colored.

A reputable nursery guarantees its stock for at least one full growing season after transplanting; preferably, it is guaranteed for a complete year. Prospective purchasers would be wise to check the extent of this responsibility in addition to the visible indications of strong and healthy stock.

NANCY M. PAGE

(All photos by the author.)

Table I.
Height relationship to caliper for shade trees.
(From American Standard for Nursery Stock. 1973)

<table>
<thead>
<tr>
<th>Caliper</th>
<th>Average Height Range</th>
<th>Maximum Heights</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\frac{1}{2}$ to $\frac{3}{4}$ in.</td>
<td>5 to 6 ft.</td>
<td>8 ft.</td>
</tr>
<tr>
<td>$\frac{3}{4}$ to 1 in.</td>
<td>6 to 8 ft.</td>
<td>10 ft.</td>
</tr>
<tr>
<td>1 to 1$\frac{1}{4}$ in.</td>
<td>8 to 10 ft.</td>
<td>11 ft.</td>
</tr>
<tr>
<td>1$\frac{1}{4}$ to 1$\frac{1}{2}$ in.</td>
<td>8 to 10 ft.</td>
<td>12 ft.</td>
</tr>
<tr>
<td>1$\frac{1}{2}$ to 1$\frac{3}{4}$ in.</td>
<td>10 to 12 ft.</td>
<td>14 ft.</td>
</tr>
<tr>
<td>1$\frac{3}{4}$ to 2 in.</td>
<td>10 to 12 ft.</td>
<td>14 ft.</td>
</tr>
<tr>
<td>2 to 2$\frac{1}{2}$ in.</td>
<td>12 to 14 ft.</td>
<td>16 ft.</td>
</tr>
<tr>
<td>2$\frac{1}{2}$ to 3 in.</td>
<td>12 to 14 ft.</td>
<td>16 ft.</td>
</tr>
<tr>
<td>3 to 3$\frac{1}{2}$ in.</td>
<td>14 to 16 ft.</td>
<td>18 ft.</td>
</tr>
<tr>
<td>3$\frac{1}{2}$ to 4 in.</td>
<td>14 to 16 ft.</td>
<td>18 ft.</td>
</tr>
<tr>
<td>4 to 5 in.</td>
<td>16 to 18 ft.</td>
<td>22 ft.</td>
</tr>
<tr>
<td>5 to 6 in.</td>
<td>18 ft. and up</td>
<td>26 ft.</td>
</tr>
</tbody>
</table>

Examples of trees in this category:

- *Acer rubrum*, *A. saccharinum*
- *Betula* spp.
- *Fraxinus americana*, *F. pennsylvanica*
- *Ginkgo biloba*
- *Gleditsia triacanthos*
- *Liriodendron tulipifera*
- *Platanus* spp.
- *Populus* spp.
- *Quercus rubra*, *Q. macrocarpa*, *Q. phellos*,
  - *Q. palustris*
- *Salix* spp.
While shade trees of slower growth may not attain the height-caliper relationship indicated above, their heights should not be less than two-thirds the height relationship given above.

Examples of trees in this category:
- Aesculus spp.
- Celtis spp.
- Cladrastis lutea
- Fagus sylvatica
- Koelreuteria paniculata
- Laburnum anagyroides
- Liquidambar Styraciflua
- Nyssa sylvatica
- Quercus alba
- Sorbus spp.
- Tilia cordata, T. euchlora

Table II.
Height relationship to caliper and branching for small upright trees.
(From American Standard for Nursery Stock. 1973)

<table>
<thead>
<tr>
<th>Height</th>
<th>Caliper and Branching</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 to 3 ft.</td>
<td>5/16 in. caliper, 3 or more branches</td>
</tr>
<tr>
<td>3 to 4 ft.</td>
<td>7/16 in. caliper, 4 or more branches</td>
</tr>
<tr>
<td>4 to 5 ft.</td>
<td>9/16 in. caliper, 5 or more branches</td>
</tr>
<tr>
<td>5 to 6 ft.</td>
<td>11/16 in. caliper, 6 or more branches</td>
</tr>
<tr>
<td>6 to 8 ft.</td>
<td>7/8 in. caliper, 7 or more branches</td>
</tr>
</tbody>
</table>

Examples of trees in this category:
- Crataegus spp.
- Halesia spp.
- Malus spp.
- Prunus cerasifera 'Thundercloud'
- Prunus serrulata, P. subhirtella
- Styrax
- Syringa amurensis japonica

Table III.
Height relationship to branching for small spreading trees.
(From American Standard for Nursery Stock. 1973)

<table>
<thead>
<tr>
<th>Height (ft.)</th>
<th>Branching</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-3</td>
<td>4 or more branches</td>
</tr>
<tr>
<td>3-4</td>
<td>5 or more branches</td>
</tr>
<tr>
<td>4-5</td>
<td>7 or more branches</td>
</tr>
<tr>
<td>5-6</td>
<td>8 or more branches</td>
</tr>
<tr>
<td>6-8</td>
<td>8 or more branches</td>
</tr>
</tbody>
</table>

Examples of trees in this category:
- Acer palmatum, A. griseum
- Cornus spp.
- Lagerstromia indica
- Magnolia soulangeana, M. stellata
- Malus sargentii
- Viburnum prunifolium
Table IV.

Relationship between ball size and height or caliper.
(From American Standard for Nursery Stock. 1973)

<table>
<thead>
<tr>
<th>Caliper Inches</th>
<th>Shade Trees Types 1 and 2 *</th>
<th>Minimum Diameter Ball Inches</th>
<th>Trees Types 3 and 4 **</th>
<th>Minimum Diameter Height Feet Ball Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\frac{1}{2})–(\frac{3}{4})</td>
<td>12</td>
<td></td>
<td>2–3</td>
<td>10</td>
</tr>
<tr>
<td>(\frac{3}{4})–1</td>
<td>14</td>
<td></td>
<td>3–4</td>
<td>12</td>
</tr>
<tr>
<td>1–1(\frac{1}{4})</td>
<td>16</td>
<td></td>
<td>4–5</td>
<td>14</td>
</tr>
<tr>
<td>1(\frac{1}{4})–1(\frac{1}{2})</td>
<td>18</td>
<td></td>
<td>5–6</td>
<td>16</td>
</tr>
<tr>
<td>1(\frac{1}{2})–1(\frac{3}{4})</td>
<td>20</td>
<td></td>
<td>6–7</td>
<td>18</td>
</tr>
<tr>
<td>1(\frac{3}{4})–2</td>
<td>22</td>
<td></td>
<td>7–8</td>
<td>20</td>
</tr>
<tr>
<td>2–2(\frac{1}{2})</td>
<td>24</td>
<td></td>
<td>8–9</td>
<td>22</td>
</tr>
<tr>
<td>2(\frac{1}{2})–3</td>
<td>28</td>
<td></td>
<td>9–10</td>
<td>24</td>
</tr>
<tr>
<td>3–3(\frac{1}{2})</td>
<td>32</td>
<td></td>
<td>10–12</td>
<td>26</td>
</tr>
<tr>
<td>3(\frac{1}{2})–4</td>
<td>38</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4–4(\frac{1}{2})</td>
<td>42</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4(\frac{1}{2})–5</td>
<td>48</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5–5(\frac{1}{2})</td>
<td>54</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Standard and slow growing shade trees.

** Small upright and small spreading trees.

Table V.

Relationships among root spread, caliper, and height of bare root nursery grown stock.
(From American Standard for Nursery Stock. 1973)

<table>
<thead>
<tr>
<th>Caliper</th>
<th>Average Height Range</th>
<th>Minimum Root Spread</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\frac{1}{2}) to (\frac{3}{4}) in.</td>
<td>5 to 6 ft.</td>
<td>12 in.</td>
</tr>
<tr>
<td>(\frac{3}{4}) to 1 in.</td>
<td>6 to 8 ft.</td>
<td>16 in.</td>
</tr>
<tr>
<td>1 to 1(\frac{1}{4}) in.</td>
<td>8 to 10 ft.</td>
<td>18 in.</td>
</tr>
<tr>
<td>1(\frac{1}{4}) to 1(\frac{1}{2}) in.</td>
<td>8 to 10 ft.</td>
<td>20 in.</td>
</tr>
<tr>
<td>1(\frac{1}{2}) to 1(\frac{3}{4}) in.</td>
<td>10 to 12 ft.</td>
<td>22 in.</td>
</tr>
<tr>
<td>1(\frac{3}{4}) to 2 in.</td>
<td>10 to 12 ft.</td>
<td>24 in.</td>
</tr>
<tr>
<td>2 to 2(\frac{1}{2}) in.</td>
<td>12 to 14 ft.</td>
<td>28 in.</td>
</tr>
<tr>
<td>2(\frac{1}{2}) to 3 in.</td>
<td>12 to 14 ft.</td>
<td>32 in.</td>
</tr>
<tr>
<td>3 to 3(\frac{1}{2}) in.</td>
<td>14 to 16 ft.</td>
<td>38 in.</td>
</tr>
</tbody>
</table>

(Tables I through V are reprinted with permission of the American Association of Nurseries, Inc.)
Literature Cited


