BRINGING ORDER TO THE TECHNICAL DYSFUNCTION WITHIN THE URBAN FOREST[1]

by James Urban

In order to increase the success rate of trees planted in the urban environment, there must be a significant change in the way trees are planted. The wide diversity in soil conditions found within urban areas suggests that there should be modifications to planting details from one site to another. The profession of urban forestry and landscape architecture, however, continue to use the same planting details regardless of the quality of the existing soil. Further, no protocol exists to guide the decision making process to determine when to use different methodologies.

This paper will present the framework for such a methodology and a series of possible changes to the way trees should be planted. The methodology is based on quantifiable levels of urbanization and soil quality, and proposes a logical approach to the design of planting details.

A major impasse to the development of a healthy urban forest is the technical dysfunction within the professions of urban forestry and landscape architecture with respect to the details of planting trees. The average professional knows little about how a tree actually grows. They are not skilled in the mechanics and dynamics of soil, roots and water and they are not aware of the impact these dynamics have on performance. Current planting practices are designed for the most benign sites; where soil is generally suitable to support root growth, is well drained, and is available in large quantities. Unfortunately, the urban forest is a continuum of soil conditions which range from these good sites to sites that have little or no drainage and where the soil is of such inferior quality and structure that it will not allow root penetration or function.

Urban forestry practices have largely relied on tree selection or "the right tree in the right place" as the primary method to overcome more difficult sites. Current research suggests that many urban sites are so severe that no species will reliably work. Modification of the site soil and drainage capability is often the only solution to successful growing of trees. On better sites, modification of the planting area could be used to broaden the number of species that will be predictably successful.

Predictability and success are the key words. When a professional forester or landscape architect is relied upon to specify a tree planting, the person investing in the cost of the tree should have some reasonable assurance that the tree will grow to meet some predetermined level of success. It is one of our profession's obligations to either ensure that the site is made suitable for the trees' growth potential or to define for our clients how much growth they should expect out of a given tree in a given site.

Site modification, however, is expensive and requires specific solutions for each problem. Currently, there are few guidelines or standards to assist in the designing of site modification procedures. Practitioners who attempt to propose new planting details are often viewed as extravagant and individual designers often come up with widely varying solutions to similar problems. The following protocol is proposed to begin to set standards for site modification and the design of planting sites. It is designed as a guide to help predetermine how much site modification is necessary to successfully grow large trees. The protocol is based on the principle that soil is the primary factor influencing tree growth in urban areas. It is necessary for a tree to have access to sufficient rooting space in order to grow properly. Since both soil quality and soil quantity are critical to the equation, a methodology is proposed to accommodate each factor.

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Site Modification Protocol

Step one - *Determining Soil Quality.* Soil quality is primarily a function of how much the soil has been graded or disturbed and how much the soil has been compacted. Each site (or portion of the site) should be evaluated to predict what the conditionof the soil will be after construction is completed. While soil quality is a continuum, the protocol will establish four classifications of soil quality as follows: 1) not graded and not compacted, 2) not graded but compacted, 3) graded but not compacted, 4) graded and compacted (Figure 1).

Definitions. The term *graded* is defined as a soil that has had its 'A' horizon disturbed, removed and not replaced or a soil that has had its 'A' and 'B' horizon moved from one location to another. The term *compacted* is defined as a soil that has been compressed to a bulk density which prohibits root growth (greater than 1.6 gr/cm). it is very difficult to predict how much the construction process will compact soil. Worse case assumptions should be used.

Step two- *Determining Level of Urbanization.* The second soil factor affecting tree growth is the quantity of soil available to the tree. This protocol chooses to measure urbanization or the aggregate of total development on a site, as an effective measuring gauge of the amount of soil "likely" to be available. Urbanization actually affects two important elements. One, the amount of soil left as available to the tree, and two, the amount of resources available per tree to modify the planting site. The higher the intensity of use of a site, the more money that may be spent on tree planting. Urbanization, like soil disturbance, is a continuum. For the purpose of this protocol, levels of urbanization will be defined based on the % of impervious surface remaining after construction, as follows: 1) less that 15%, 2) 15% - 50%, 3) 50% - 75%, 4) 75% - 90%, 5) 90% or greater (Figure 2).

Step three - *Find the Sites Minimum Design Criteria.* Soil disturbance and urbanization are put on the axis of the Minimum Design Criteria Matrix (Figures 3 & 4). In each of the resulting 20 positions are recommendations for minimum design criteria to be used when preparing planting details. The recommendations are made for the three critical design elements that affect tree growth. These are soil modification, drainage modification and aeration modification. The recommendations are made using a numerical code which is referenced in the following sections. By using these criteria, minimum details can be developed. Not all situations, however, will match these criteria. If conditions exist which suggest that a different criterion would be more appropriate, then it may be substituted provided that the designer understands the impact on the tree of this change.

Soil Modification Procedures

The following list describes optional methods of soil modification that can be included into planting

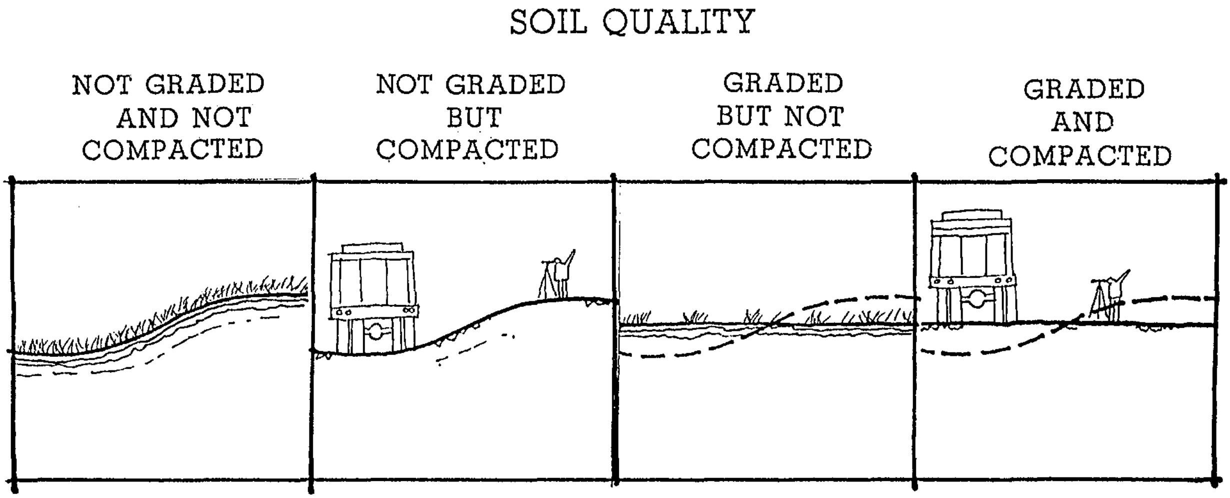


Figure 1

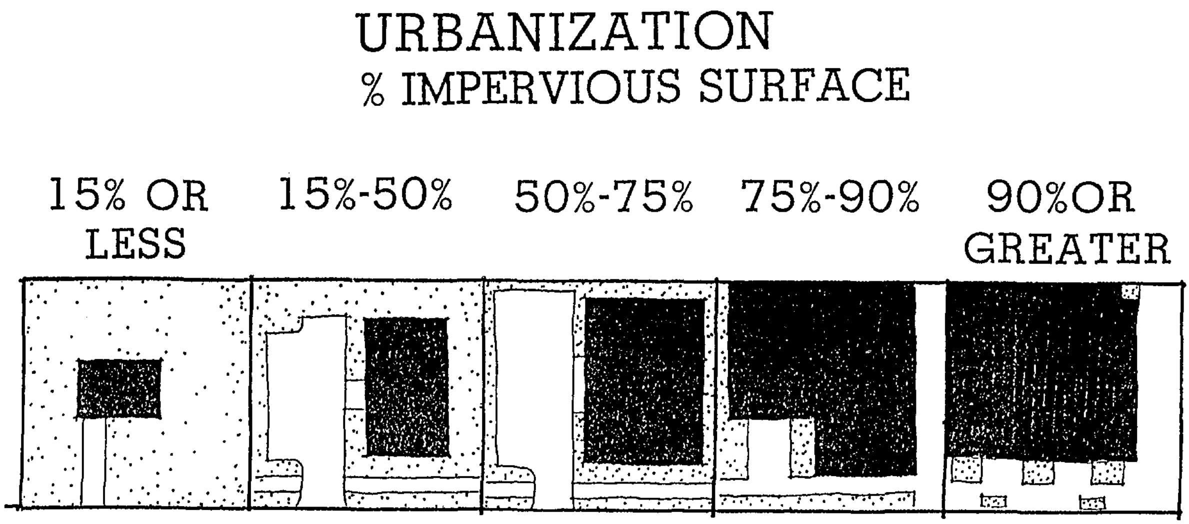


Figure 2

details. They are ranked from the least to the most complex of procedures. Providing enough soil, of suitable quality to support the tree mass proposed in a given location must be accounted for in the earliest phases of the project.(The codes refer to Figure 4.)

S1. Dig the planting hole 60 cm (24 in) larger in diameter than the diameter of the root ball. Back fill with the unamended soil excavated from the hole

S2. Dig the planting hole 180 cm (6 ft) larger in diameter than the diameter of the root ball. Back fill with the unamended soil excavated from the hole.

MINIMUM DESIGN CRITERIA MATRIX

GUIDE

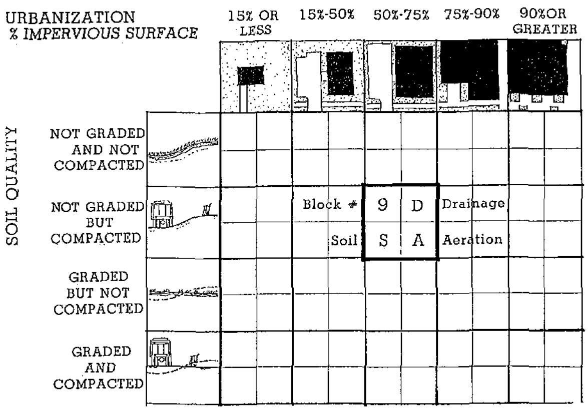


Figure 3

S3. Dig the planting hole 180 cm (6 ft) larger in diameter than the diameter of the root ball. Excavate the remaining areas of soil in planters and lawn to a depth of 20 cm (8"). Till the resulting subgrade with the first 10-15 cm (4-6 in) of planting soil mix.

S4. Excavate all areas available for planting and lawn to a depth of 75 cm (2.5 ft). Till the resulting subgrade with the first 10-15 cm (4-6 in) of planting soil mix. Calculate the quantity of planting soil mix to determine that the volume of soil per tree being provided is sufficient to grow the tree specified (Figure 5). Modify the design to allow for adequate soil volume.

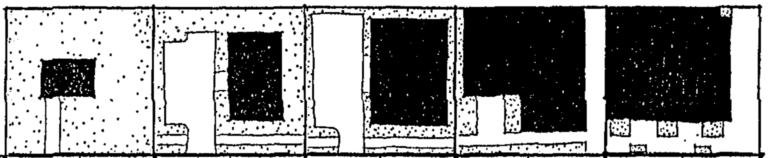
S5. Perform the requirements of Step S4. Design additional subsurface soil volumes below the adjacent paving as required to provide all adequate soil volume (Figure 5). Interconnect these soil volumes whenever possible.

Definitions:

Planting soil mix. A sandy loam comprised of a majority of medium to coarse sands. This soil should have a percolation rate when fully compacted of at least 2 inches per hour.

Soil volume. All soil that is available to the roots of the tree that is of suitable quality for root

MINIMUM DESIGN CRITERIA MATRIX



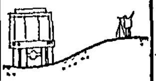
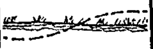
URBANIZATION % IMPERVIOUS SURFACE		15% OR LESS		15%-50%		50%-75%		75%-90%		90%OR GREATER	
SOIL QUALITY											
NOT GRADED AND NOT COMPACTED		1	D1	3	D1	6	D1	10	D2	14	D2
		S1	A1	S1	A1	S2	A1	S2	A2	S3	A2
NOT GRADED BUT COMPACTED		2	D1	5	D1	9	D2	13	D2	17	D3
		S1	A1	S2	A1	S2	A2	S3	A2	S4	A3
GRADED BUT NOT COMPACTED		4	D1	8	D2	12	D2	16	D3	19	D3
		S1	A1	S2	A2	S3	A2	S3	A2	S5	A4
GRADED AND COMPACTED		7	D2	11	D2	15	D2	18	D3	20	D3
		S2	A2	S3	A2	S4	A2	S4	A3	S5	A4

Figure 4

growth (well drained, not compacted, and possessing adequate pore space). The maximum depth for this calculation is normally 75 cm (2.5 ft).

Drainage Modification Procedures

The following list describes optional methods of drainage modification that can be included in planting details. They are ranked from the least to the most complex of procedures. Adequate drainage is required to obtain root growth in the soil. Soil modification without attention to drainage can lead to saturated soils that will not support tree growth. (The codes refer to Figure 4.)

D1.1. Percolation of existing soil 5 cm (2 inches) per hour or greater. Provide positive surface drainage, minimum of 2%.

D1.2. Percolation of existing soil 2.5-5 cm (1-2 inches) per hour. Increase surface slopes in planting areas to 10% away from the tree.

D1.3. Percolation of existing soil less than 2.5 cm (1 inch) per hour. Mound planting soil in the area of the tree at 20% so that the root ball is entirely above the existinggrade and/or add subsurface drain lines around the tree and loosen the soil to a depth of 30 cm (12 in).

D2. Unpredictable percolation. Move existing water away from the site by providing subsurface drain lines within the planting area and/or provide a drain sump pit at each tree. Perform a percola-

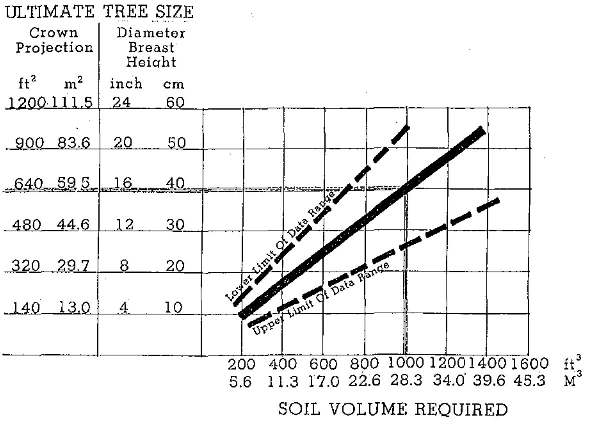


Figure 5. The data on this chart represent a synthesis of several studies attempting to establish the relationship between tree growth and soil volume. See citations 7,8,9,13.

tion test at each tree. Apply criteria of D1.1 - D1.3 above.

D3.1. Trees within new paving, provide subsurface drain lines to remove water from the site which connect from tree to tree.

D3.2. Trees within existing paving, perform a percolation test. If the percolation of the existing soil is 2.5 cm (1 in) per hour or greater, install drainage sump with subsurface drain line ring around the tree. If the percolation of the existing soil is less than 2.5 cm per hour, **do not plant** the tree unless drainage can be improved.

Definitions

Percolation test. Dig a hole 15 to 25 cm (6 - 10 inches) in diameter and 25 cm deep, fill the hole with water and allow it to drain. Refill the hole with water and measure the rate of water percolation out of the hole.

Drainage sump. A hole 20 to 30 cm (8 - 12 inches) in diameter by at least 1 m (3 ft) deep measured from the bottom of the planting hole. Insert a 10 cm (4 inches) diameter perforated pipe which extends up to grade and backfill with coarse gravel. Drainage sumps are only effective if they reach a pervious layer.

Aeration Modification Procedures

The following list describes optional methods of aeration modification that can be included in planting details. They are ranked from the least to the most complex of procedures. The ability of soils to conduct air to the root zone is critical. Where soil volumes are restricted, new details, which allow more air to get deeper into the soil, will greatly increase the effectiveness of the available soil. (The codes refer to Figure 4.)

A1. Provide for periodic aeration and/or mulching of the ground within the dripline of the tree.

A2. Provide aeration sheets along accessible surfaces, i.e., foundations, curbs, etc.

A3.1. With existing paving, provide aeration sheets within the planting area.

A3.2. With new paving, provide aeration sheets within the planting areas and under paved areas. Install coarse gravel subbase under all paved areas. Install open joint unit pavers where applicable.

A4. Install watering tubes within the gravel subbase plus provide A3 requirements.

Definitions

Aeration sheets. Three dimensional drainage cores covered on both sides with a geotextile fabric. The sheets should be 30 to 45 cm (1 -1.5 ft) wide and be placed in a vertical position in order to be effective. Aeration sheets are currently made by: American Enka Co., Enka, NC (Enka Drain # 9228); American Wick Drain Corp., Matthews, NC (Akwa Drain 112) and Mirafi Corp., Charlotte, NC (Miradrain 4000).

Watering tubes. Five cm (2 in) diameter perforated tubes that conduct water from a surface source into the gravel under the paving.

Other Determinants That Affect Tree Growth

There are a number of other factors that affect planting detail design but are not easily accounted for in this protocol. Each of these will have to be considered by the designer and appropriate modifications to the recommendations must be considered.

Soil Texture. Extremes of very sandy, silty or clayey soils are not accounted for in this protocol. When these soils are encountered, follow the recommendations of a soil scientist.

Soil Profile. Unusual soil profiles such as fragipans, hardpans, shallow rock formations or under-ground structures will require special details.

Site History. The age of the buildings and site work can have a significant impact on the opportunities for root growth. Sites developed prior to 1940 may require less site modification to grow successful trees due to the differences in the way land was developed. Sites that have had several changes in the configuration of buildings and grades may require more site modifications than may be indicated by the protocol. Each layer of change introduces disruption to the soil structure that is often hard to determine by visual site inspection.

Project Maintenance. These recommendations assume that some minimum maintenance will be available on a long term basis. This would include regular pruning, watering during the initial transplant period, and some ongoing insect and disease control. Less maintenance will require more site modification to grow similarly sized trees while more maintenance, particularly irrigation and fertilization, will allow for slightly less site modification.

Conclusions

The state of urban forestry must continue to evolve if successful urban forests are to be grown and maintained. New partnerships and institutions will have to be forged and new standards will have to be set. Much of the technical information we currently rely on will have to be set aside in favor of new ideas that will be based on research and documented experience. The protocol for tree planting detail design outlined above is only one small step in this process.

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