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TREES IN THE LANDSCAPE: A Look Beyond the Obvious[1]

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The title of my remarks is intended to suggest a look at the use of trees in the landscape in a context that is broader than the commonly accepted usages of shade and beautification. For too long a time trees have been touted on the basis of appealing to the imagination and emotions rather than appealing to reason and function. The use of trees in the landscape must be put in proper perspective.

If trees are to be used in cities to the extent they should be, we are going to have to do more than recommend them on the basis of beautification and shade. We must become well informed and conversant with the engineering, architectural and environmental functions of trees. Armed with these facts, it will be possible to convince the hard-nosed developer, business man and politician that there is economic soundness in the investment in trees in the landscape. This is important since each of these groups makes judgments on the basis of the economic return for the dollar invested. Therefore, it seems appropriate to launch this educational effort in the International Shade Tree Conference on the occasion of your 50th Anniversary. I am convinced that this approach will be a valuable tool for you to use when called upon to recommend trees for use in a landscape setting.

It is for this reason my presentation is entitled "Trees in the Landscape: A Look Beyond the Obvious". I want to talk about the use of trees in landscape design where trees not only provide shade and beauty but at the same time serve to contribute to the effective functioning of the site. Because my talk is restricted just to the use of trees in the landscape, it's incumbent upon me to establish the tree in its proper relation to all other landscape materials both plant and architectural. The tree is not the only element essential in design. Many other factors are equally or even more important, but the proper selection and placement of trees makes the difference between success or failure of a landscape design.

As you know all professors have to start a discussion with a definition. What I wish to define is landscape design—the creation of space for use by people. How people react to this space is of primary importance. Let me illustrate. (Note: Demonstration of man in open space, man enclosed in space with vertical emphasis and man enclosed in normal ceiling height space). I am not going to discuss genus, species, growth habit, soil preference, hardiness, resistance to disease and insects, sun or shade requirements which you as members of the ISTC know very well. Rather I want to consider trees as a unique landscape design element that offers the opportunity for creating space for people, to establish a feeling of scale and to develop a harmony with the surroundings. Whenever we place trees along with other landscape elements (fences, walls, shrubs, surfacing materials, buildings,

1. Presented at the 50th International Shade Tree Conference in Atlanta, Georgia in August, 1974.

etc.) on the ground the result is the formation of space. The quality of the resulting space determines if our use of materials is good or bad. It should be space that is pleasing to walk through, inviting to sit in and comfortable to use in general. Scale is the relative size of any object when compared to adjacent buildings, space or other objects. If the size of a tree used in a design is comparable to the size or surrounding buildings and space, the design has good scale. Good scale helps people to become oriented and to understand the immediate environment.

Finally, harmony with surroundings refers to the selection of trees that are appropriate in the degree of enrichment they contribute to the space and in their role of strengthening and reinforcing the function and purpose of the space. Harmony implies an influence not only on the space being developed, but also on surrounding spaces off the site. For example, one of the most effective ways to integrate a new development into the existing pattern of landscape in the region is to use trees native to the area. Native trees combined with those that naturally grow in association with the natives produce a most satisfactory landscape composition because they complement one another in color and texture, and they have similar cultural requirements. The process of weaving together the new with existing patterns of landscape, however, can also be done using ornamentals not indigenous to the area.

Now to come back to my previously established thesis, not only should beauty be an unquestionable part of landscape developments, but the functional capabilities of trees must be exploited if we are to justify their use in the urban environment. To help you understand the functional use of plants, I am using the classification, although somewhat modified, that G.O. Robinette established in his book *Plants, People and Environmental Quality*. These categories are engineering, architectural and environmental.

Engineering Functions

Engineering problems that can be solved or at least modified by landscape planting include traffic control, noise control, light control (glare and reflection), and soil erosion. For example, if properly selected and placed, trees can direct and control vehicular and pedestrian movement, reduce irritating and disturbing noises that penetrate areas of human activity, control natural and artificial light that interferes with human use and comfort and stop erosion of soil by wind and water.

Admittedly, planting designers have used plants for some of these purposes for many years. To a large extent, this was based on intuition rather than fact. Now a substantial collection of technical data is available to document the abilities of plants to perform these functions, once again I refer you to Robinette's publication.

Whether or not a plant can serve as an engineering unit is based on the character of its foliage, its branches, its bark and its roots. Each characteristic has a special function according to the engineering problems to be solved. Planting design is and should be one of the last steps in the design process—but never should it be an afterthought. By that I mean the site planner must work out the total land-use, the interrelationship of activities and the basic functions of space being developed. Then, the planting designer can use his knowledge of plants, rate of growth, habit, form, color and texture to reinforce, articulate, strengthen the design.

Trees may be used as a means of controlling both pedestrian and vehicular traffic. This has a somewhat negative connotation—keeping people and cars where you want them. But it is also positive in the sense that people can have a fuller enjoyment of the space when the layout and direction of movement are defined and controlled. It relieves them of the confusion and indecision that takes over when movement through space is random and uncontrolled.

Trees can be used effectively in channeling traffic by outlining the walk or drive to follow. They help to provide a feeling of enclosure and separation from surrounding space by the even spacing of each tree. Trees help identify our destination by the line and direction they establish. Finally, trees enhance the area that otherwise would be cluttered with chains, posts

and wires.

Obviously trees do not provide a solid barrier for traffic control if spaced along the route. The degree of control required must be understood. If the control must be total and complete, shrubs will be more appropriate. On the other-hand, there are tree types that form a dense mass from the ground up; and, when closely spaced, they provide a solid border for complete movement control. The choice between the shrub or tree in this case will be dependent on the scale of the space, proximity of people to the barrier and the need for visual access to the surrounding areas.

As you select trees for traffic control, consider spacing and density, width of the crown, and height. Spacing of trees results in openings between that allow pedestrian movement through the opening. Obviously if complete control is desired, trees will not work. But this spacing is good where less rigid control is needed. You also have the advantage of implied enclosure because of the rhythmic repetition of the tree trunk and the canopy of foliage overhead. The width of the tree must be considered in terms of the space available for crown development. Finally height is a factor that relates to the trees physical relation to surroundings and the psychological relation to people. As mentioned before a good scale relationship between buildings, site and trees is important. However, the height of the tree in relation to people has a tremendous psychological effect on them. This is judged on the basis of the size of the human body in relation to the size of the tree. If the two units are well proportioned we have satisfying and comfortable human space. If there is a dramatic disparity between the two the result is a feeling of being overwhelmed and dwarfed. This is a disturbing relationship.

Noise that is excessive or unwanted is another engineering problem that can be reduced or controlled by plants to a certain extent. Sound is transmitted by sound waves which have a pitch or frequency. High frequency sound waves have the shortest length, and low frequency sound waves have the longest length. These waves are transmitted by wind but the degree of transmission is based on the humidity of the air. High humidity results in low transmission and the reverse is also true. Sound is reduced in intensity either by the distance it travels or colliding with a barrier between the source and the area to be protected. Therefore, the source must be identified. The source of noise can be grouped as linear (highways); spot (ball field); and area (airport or industry). Before sound can be modified the source must be considered as well as methods by which sound can be reduced.

The reduction of sound is achieved by absorbing the soundwaves, by reflecting them back toward the source and by deflecting them to another area. Refraction is the dissipation of sound by introducing a rough surface to absorb and break-up the sound waves while masking is the introduction of a pleasant sound (water for example) to override the offending sound.

Trees function in the sound reduction process by modifying humidity and climate, by absorbing sound and by deflection and refraction. Noise control is one function where trees perform their role much more effectively when combined with earth, structures or shrubs to provide a more complete barrier.

Problems of glare and reflection from the sun and artificial lighting can be resolved by proper tree selection and placement. Some common sources of glare and reflection are water, sand, gravel and rock surfaces. Many manmade surfaces such as glass, metal, pavements and other architectural materials add to the problem. Through the use of trees we can screen, filter and soften glare and intercept and block reflection if care is taken to select plants with the proper height, shape and density. The sun can be controlled by planting trees close to windows and in critical spaces where filtering of light is necessary for human comfort. Tree placement between stationary night lights and the viewer or perhaps a building eliminates undesirable light penetration.

When working to eliminate reflection, trees can be used to reduce the intensity of secondary glare by intercepting the light before it hits the surface or after it strikes the reflecting surface to block the light from reaching the viewers eyes.

The final engineering function for trees is soil erosion both by wind and by water. The extent of erosion in an area depends on the character of the soil, the extent it has been disturbed by man and the length and degree of slope. Wind blowing across exposed soil lifts particles and carries them some distance before depositing them again. Trees functioning as windbreakers can slow this damaging process. To be effective as a windbreak the tree should have dense leaves or needles extending to the ground.

Water erosion results from the impact of rain on bare soil which dislodges particles that are then carried away by the water runoff. Trees can reduce this process by the canopy and leaves intercepting raindrops thereby breaking the velocity of impact on the soil. Horizontal branching further controls water movements from speeding down the trunk as does a rough bark. And of course a fibrous root system is also one of the most effective agents for reducing erosion. Here again trees are most effective when combined with shrubs and ground cover to reduce the effects of grading and changing natural landforms.

Architectural Functions

Trees can be used as single specimens or in groups to define and articulate space, to provide privacy, to screen views and to control the spatial experience and make it more interesting for people. These are called architectural uses of trees.

Space articulation is simply the subdivision of large undefined space into small units either by defining, enclosing, or delimiting space. In some situations trees can perform this architectural function exclusive of other materials and in other cases trees combined with other landscape elements will be required.

To use trees effectively you must understand and analyze the spaces created by the other design elements—buildings, roads, etc. In this way you can determine if trees are needed to reinforce the design or just to refine and control the spatial experience. It is important to recognize and respect the concepts of the original designer. Once familiar with these concepts you can then proceed to determine how to best use trees to provide space organization, recognition, modulation and articulation.

Tree plantings can be used to direct the movement and vison of people first to the primary or important spaces, then to those of less importance. But to do this you have to understand the hierarchy of spaces as conceived by the site planner then reinforce these by proper selection and placements of plants.

I have already alluded to the fact the large, undefined space is incomprehensible. Therefore our goal in design should be to break this space down into smaller, more easily understood units. This process is called modulation by Robinette. To accomplish this, trees, along with other plants, may be used to subdivide and define these smaller spaces.

Trees can also be used to help people to understand the functions of spaces. This is done by reinforcing functions and interpreting them to the users. For example trees can be arranged to give direction and encourage movement through a space. The skillful use of form, texture, and color can direct the vision of a person in such a way he feels compelled to move on to other spaces.

The use of trees to finish off or complete space is a common architectural function. For example trees may be arranged to close off space that had been left open by architect. In this case, trees are used to make the space visually complete and perhaps more usable. Or trees can be used to enframe a view or the most important space of the overall development. The enframement technique is like framing a picture on the wall. The purpose is to direct the viewer's eye and attention to that which is most important. Finally, as articulators trees can enlarge or reduce space. By using tree forms that direct the eye upward toward the sky the immediate space in which the viewer is located will look small in comparison to the vastness of the sky. By contrast, reduction results from using trees to make excessively large spaces smaller and more comprehensible.

Screening implies the use of trees to block out that which is ugly, but it can also be used to modify a scene that you feel is inharmonious with the project being designed. In the first case

it is absolutely necessary to block the view while the latter situation suggests concealment for purposes of enhancing our own design. When selecting trees for screening you should consider the area to be screened and the angle of the view, the distance from the viewer, the elevation of the area and the speed of the viewer when he sees it. You can then select the right tree on basis of need for denseness, height, width, year around concealment, etc.

Privacy control differs from screening in that its purpose is to separate and seclude an area for special use. Privacy becomes an important consideration when population density is high. Tree selection will require choosing the proper form, size and density in relation to the amount of privacy required and the type activity planned for the area. Sitting activities do not require as high a screen as standing activities. For example you can utilize the crown of the tree for additional height over the height of a fence, wall, or plant screen. These latter elements succeed in giving privacy at eye level but cannot give privacy from elevated views in the area. Of course some trees through form and spacing can provide the privacy control desired without being combined with other landscape elements.

Environmental Functions

Environment is a word that is perhaps suffering from over-use and misuse because of its broad meaning. My use of the term refers to external conditions and influences that affect the well being of people. In this section I am including air pollution control, climate control and visual functions. It may be argued that air pollution control more logically belongs in the engineering category or that noise control belongs under this heading. My groupings are arbitrary and I would ask that you not become preoccupied with categories instead of becoming familiar with the functional role of the tree.

The most effective air conditioners in the landscape are trees. They remove and assimilate carbon dioxide and other pollutants from the air and release oxygen which is essential for man's survival. The release of oxygen is also important in the trees role as a modifier of air pollutants. With enough trees releasing a large volume of oxygen, it is possible to have an abundance of oxygen in the atmosphere around the tree. This phenomena is called oxygenation and can bring about a readjustment of the ratio of polluted air to clean air. This readjustment is the result of diluting polluted air by mixing it with oxygen enriched air. Robinette points out that air contamination acceptable to man is one part polluted air to 3000 parts of relatively pure air; but along many highways for example the ratio is 1:1000. To readjust this air balance would require a green belt one-half mile wide on either side of the highway. Again just one example to show the need for trees in urban environment to modify the pollutants in the air.

In addition trees can remove particulate matter such as fly ash, dust, and other impurities. The leaves, stems and branches of all plants trap and hold these particles but those with a slight hairiness on leaves and stem are especially effective in removing particulate matter.

Besides dilution and filtration, trees function to wash the air as a result of the transpiration process. The transpiration process causes water to form on the leaves. As this water collects it washes the particles off the leaves and onto the ground. The resulting water on and around the ground also serves to settle out wind borne pollutants. For example a beech tree loses 75 to 100 gallons of water during a single summer day, add a number of trees to this and you will have significant control over air pollutants. It should be pointed out however that trees on the edge of the city are not going to be effective in pollution reduction in the heart of the city. To do the job, trees have to be where the concentration of pollutants is greatest. Here is another strong argument for trees and green spaces in the central city. Consider also the fact that a street with trees was found to have 100-3000 dust particles per liter comapred to a street without trees where the concentration of dust particles was 10,000 to 12,000 per liter.

Climate control is an important factor in creating an environment that meets the requirements for human comfort. Human comfort can be affected by air temperature, solar radiation,

air movement, humidity and precipitation. Trees can play a major role in climate control particularly solar radiation, wind, snow and temperature control.

Solar radiation control requires the use of trees for shading direct radiation and for intercepting reflected radiation from surfaces. Shading blocks the sun's ray or filters them resulting in a measurable amount of cooling underneath the plant. Deciduous plants are particularly appropriate since they have foliage during the season when solar radiation is most uncomfortable and are without foliage when the warmth of solar radiation is welcome. Reflection reduction requires trees to be placed so they intercept sun rays either before they hit a reflective surface or after the rays strike the surface. Trees with dark foliage and small leaf surfaces are most effective in breaking down reflection.

Wind at low velocities may be pleasant but high velocities can cause discomfort and even physical damage. Canopy trees provide an incomplete barrier but they still function to modify winds; however, those with foliage carried to the ground are most effective. It is best to use plantings in a way that will obstruct the wind to reduce its speed or to deflect it from areas devoted to intense human use. Shelter belts and windbreaks are effective when placed at right angles to prevailing winds. With this arrangement wind velocity may be reduced 50% for a distance 10 to 20 times the height of the tree. The extent of such a reduction depends on the height, width and penetrability of the plant used. Even canopy trees can modify the wind.

Drifting of snow can be controlled by trees used as windbreaks and placed so as to slow the wind velocity in order to get the snow to drop on the ground in front, within, and leeward of the barrier. A solid screen results in a drift on either side of the barrier which quickly reaches a saturation point. A more open screen has a drift only on the leeward side. These drifts are shallow, extend considerable distance and absorb more snow.

Trees used for temperature control have the greatest effect by moderating the temperature close to the ground. The crown holds or reflects radiation so the shaded side has cooler temperatures than the radiated side. Shade trees also modify temperature when used to control wind patterns and the movement of hot air over the ground and buildings. Finally, deciduous trees that interfere with solar radiation and reflection cause a temperature reduction not only on the ground but also on other shaded surfaces.

Visual functions of trees embrace esthetics and quality of life. The reason for this section is to emphasize that one tree or a group of trees may perform several functions. For example, the tree or trees may be used to control an engineering problem, a climate or pollution problem, and at the same time function as an architectural unit. Such dual functions and flexibility strengthens our argument for trees in urban environment. But their functional role should not preclude exploiting the full potential of the tree's design characteristics.

We should not overlook plants as a source of strong two-dimensional effects resulting from shadow patterns and reflections in water. These patterns can be more intriguing and interesting than the plant itself.

As a three-dimensional unit a tree can be used as a sculptural element, textural element and a means of softening and contrasting the lines of contemporary architecture. And, most important, they establish a link between man and nature that is vitally important within our harsh and cold city environments. The fact that trees are constantly changing hourly, daily and seasonally gives movement, character and life to the scene. This is an important element in keeping one's sanity in a bleak, negative and inhuman environment. Trees are attractors as well as diverters. They attract birds, animals and people because of their color, form, texture, and shade; and when properly used, they divert attention from offending views.

Trees are used to give visual coherence to the urban landscape. They can pull together disparate elements and give a uniformity and harmony to a diverse, chaotic, unorganized scene. Furthermore, trees can be used to indicate the significance and importance of space or to indicate an event or a memorial.

Finally, trees can affect people's moods because of their sense of shelter, permanence, and individuality

At the beginning I suggested trees should be considered in terms of creating space, establishing scale and providing a harmony with the surrounding. Now I would like to conclude with a few general comments about designing with trees—an approach to composition.

As is true with any design discipline there are no hard and fast rules to offer. But I can give you some general guidelines. The arrangement of trees should first satisfy the functional role they are to perform. Next the sense of enclosure of space, scale and harmony must be worked out. Within this framework the arrangement of groups of trees and specimen trees should aim to provide interest, variety and pleasure. This means we have to avoid the monotony and dullness from the unimaginative placement of trees at equal distances apart like orchard trees—all bolt upright and all trained to the same outline.

The most important ingredient for a successful composition is the ability to visualize in the minds eye what each tree looks like in youth in different seasons and in its maturity. Trees change constantly but predictably in shape, color and size. These must be anticipated by the designer if he is to capitalize on these changes thereby exploiting to the fullest the potential contribution of each tree used in the design.

I do not mean to suggest that your design should be composed of one each of every tree available. This results in an arboretum. In fact, just the opposite approach should be followed. Select one tree species to be used in greater quantity than any other. If the site you are working on has several principle spaces to be designed, this dominant species should be used in each of them. The repetition which the viewer can recall from area to area gives a unity to the design that is very satisfying.

Restricting the number of different tree species and varieties used avoids the development of a design that calls attention to itself rather than being an integrated and unified composition. The concept of limiting the numbers of different trees is especially important when working close to buildings. Too much variety and change competes with and distracts from the architecture.

Besides serving their functional role, the arrangement of trees in the design should be bold and dramatic. We cannot and should not try to duplicate nature's natural woodlands. The setting for the design is man built and the use of trees should also reflect man's control. Therefore, grouping of large and small flowering trees of a single variety in both close and more open spacing is the most effective design technique. When you want to emphasize a point in the overall landscape or to draw the eye toward or away from some element, an individual, specimen tree can be used. Trees used as specimens are those that are outstanding and perhaps unique in one or more of its basic design qualities of form, color or texture. Caution is necessary to avoid the over-use of specimens. When too many specimens are used, the composition loses all sense of good design and the specimen's role of creating emphasis is diminished because it is so commonplace.

Scale is another element that must be understood to assure a satisfying design with trees. Scale refers to the size of an element but in design it is also a matter of proportion. When I use the word scale, I am referring to the size of the tree in relation to the surrounding space, buildings and other objects. A good scale relationship then is a satisfying proportional relationship between all units of design. Planting in scale, and in harmony with surroundings, will mean that small trees are selected for small places (backyards, courtyards, etc.) or where large trees are needed to form the framework and background of the design. Large trees must also be used with large buildings and spaces. The best illustration of the misuse of scale is the dotting of small flowering trees along streets and highways and around large scale commercial and industrial developments that call for large, robust, strong growing trees.

In the urban landscape, the scale and settings are made primarily by buildings and streets. The individual trees are subject to close inspection with every detail—bark, twigs, foliage, flowers, fruit, texture, form and color—being observed

in close detail. Therefore, what trees are selected becomes a critical matter. You must decide if the tree should have a regular or irregular outline. Those with a regular and precise form have a strong silhouette or outline that is most suitable for architectural plantings —avenues or regular geometric patterns. Those with irregular and perhaps somewhat open outlines offer a contrast of texture, an intricacy and decoration that is rarely present in our modern buildings. Today's architecture has clean, precise lines and shiny glossy surfaces that reflect our machine age and new technological materials. In a word they lack the delight, mystery and richness of detail typical of earlier periods. For this reason trees must be used to give to the urban landscape much of this delight and richness.

In the final analysis, the landscape, public and private, rural or urban, must be designed by man for his comfort, convenience and pleasure. We must be certain that our designers are not built on meaningless pattern or contrived form. The use of trees should have more importance attached to it than just to improve the esthetic qualities of an area. We must enlighten the developer, the business man and the politician to the fact that trees have functional capabilities that help man to solve architectural, engineering, climatic, and environmental problems. I have tried to delineate some of this. Now the responsibility to prove this rests with you and how you use trees in the landscape. We need to use trees in the landscape to facilitate the human use of space, for the ultimate consumer of landscape is people!

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ABSTRACT

Hinckley, T. M. and D. N. Bruckerhoff. 1975. **The effects of drought on water relations and stem shrinkage of Quercus alba**. Can. J. Bot. 53: 62-72.

Stem circumference, xylem pressure potential (P), and leaf surface resistance were measured in a dominant forest-grown white oak tree from the beginning of, through the development of, and to recovery from a major drought in mid-Missouri. Continuous recording of several environmental variables and periodic measurements of soil moisture were made in coordination with the above plant variables. As base P and soil moisture decrease, net day-to-day and even week-to-week stem shrinkage was observed. Periodic thunderstorms alleviated soil and plant water deficits and stem circumference recovered. Excellent relationships were noted between soil moisture in the upper 30 cm of a 107-cm profile and either base P or stem circumference.

La circonférence de la tige, lepotential de pression du xylème (P) et la résistance des feuilles ont été mesurés chez un chêne blanc dominant ayant poussé en forêt. Ces mesures ont été prises depuis le début d'une sécheresse importante dans le centre du Missouri, pendant son développement et jusque dans la période de récupération. On a tenu un record continuel de plusieurs variables de l'environnement, et on a pris des mesures périodiques de l'humidité du sol par rapport aux variables déjà mentionnées. Pendant que la P basale et l'humidité du sol diminuaient, on a observé un rétrécissement net des tiges d'un jour à l'autre et même d'une semaine à l'autre. Des orages périodiques allégeaient les déficits en eau du sol et des plantes, et la circonférence de la tige regagnait sa grandeur. On a noté des rapports excellents entre l'humidité du sol dans les 30 cm supérieurs d'un profile de 107 cm et la P basale d'une part, et la circonférence de la tige d'autre part.