BARTLETT TREE RESEARCH LABORATORIES
CHARLOTTE, NC
Technical Report

Cradle to Grave; Nursery to Woodpile

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Tree management considerations must be based on an understanding of tree growth and development. Tree development from juvenility (youth) to maturity to senescence (decline) has been characterized in several ways including chronological age, size and reproductive capacity. Recently, development has been described in terms of tree energy systems.

Energy necessary to drive biological functions in trees is derived from sunlight. Chlorophyll in leaves captures energy from sunlight and stores it in chemical bonds in carbohydrates. This energy is used to support biological functions in a process called respiration. During respiration, high energy yielding bonds holding carbon, hydrogen and oxygen in carbohydrate molecules are broken, thus releasing energy. This energy fuels all biological activities in the plant including budbreak and leaf development, wood fiber development for structural support, growth, water and nutrient absorption and transport, defense and flower and seed production.

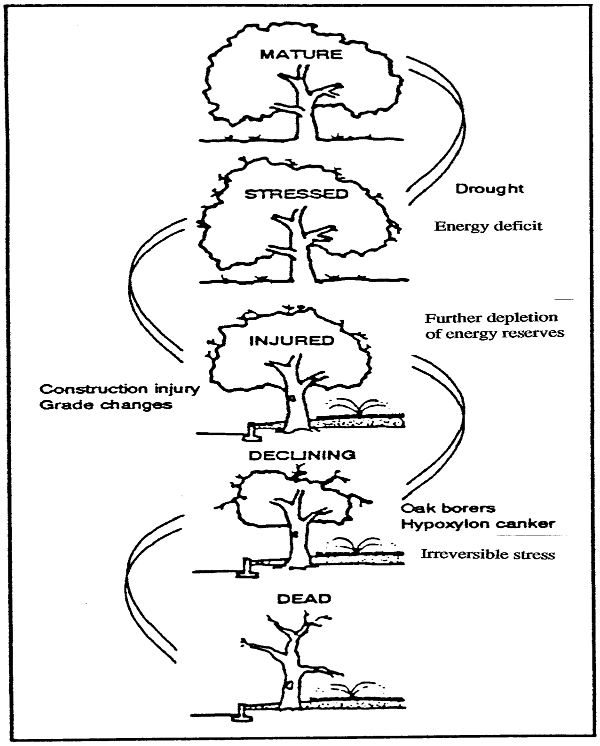
Reserve energy also is stored for "emergencies" i.e. periods of stress such as drought or defoliation by pests when annual energy production cannot meet demands. During these periods of stress, growth, defense or both may suffer at the expense of maintaining existing tissues.

Young trees have a high ratio of photosynthetic area (leaf surface) to biomass. With this high ratio, they can generate a surplus of energy, which is used to fuel rapid growth. Young trees also can tolerate change and stress because of high levels of reserve energy.

As trees mature, the ratio of photosynthetic area to biomass becomes less. Most of the annual energy generated in the leaves is dedicated to maintenance of existing tissues, defense and reproduction. Less energy is available for growth and energy reserves are minimal. Mature trees are less capable of tolerating stress or change. They are in a delicate balance with their environment.

When mature trees are exposed to stress from environmental factors, wounding, pest infestations or other reasons, growth rate slows because the tree must utilize energy reserves for maintenance of tissues and defense. (Maintenance of existing tissues and defense occurs at the expense of growth). With multiple stresses or chronic stress, energy production and reserves is further reduced and decline begins.

Declining trees have stunted growth, small leaves, premature fall coloration, and abnormally heavy crops of seed and branch dieback. These characteristics further inhibit energy production and create more demand on reserves. Declining trees become infested by "secondary invaders"



such as borers and canker and root disease pathogens. More energy reserves then must be utilized for defense. If the stress is not alleviated, the tree enters a mortality spiral, which is irreversible.
Death ultimately results when the tree is depleted of energy.

PLANNING AND PLANTING

Successful tree management programs begin with selecting species, which are compatible with the site. Large growing species in confined spaces will decline prematurely. Limited water and nutrient availability creates energy deficits soon after planting. The average life span of an inner city tree growing curbside in a tree pit is seven years. Large species beneath utilities, which must be pruned often for clearance, will also decline prematurely. Reducing crown size and constant wounding will create energy deficits, which will predispose it to decline. Matching species to site is essential to long term survival. Selection considerations should include available root space, crown space, soil type and hardiness (adaptability to temperature extremes) and resistance or tolerance to pest problems.

Arborists recognize that some trees decline and die at an early age. Fast growing species such as silver maple, poplar and willow generally have a shorter life span than trees with slower growth. Fast growing trees generally allocate more energy for growth and less energy for defense. These trees are often poor compartmentalizers and more prone to life threatening pest problems. When allocating resources for tree management, emphasis should be directed at planting trees with long life spans.

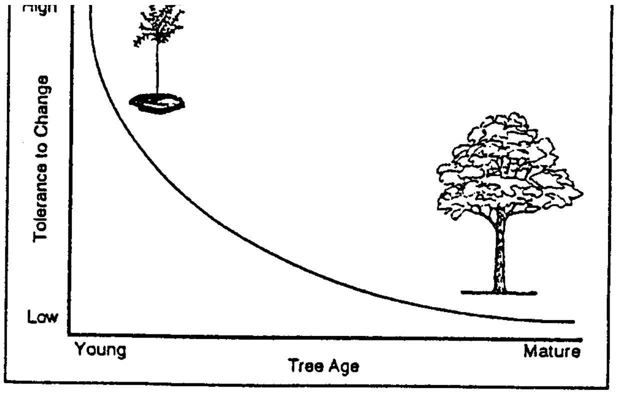
Small caliper nursery stock regenerates a root system to pre-transplant levels more quickly than larger transplants. This translates into higher survival rates and lower maintenance costs during the establishment period. Crown growth rates of small transplants are much faster than larger stock following transplanting. After a ten-year period, two-inch transplants will be a similar size to ten-inch stock. In general, 2 - 2 1/2" caliper stock is recommended. Larger sizes may be necessary in high use areas where vandalism is a factor.

Proper planting techniques are essential to assure tree establishment. "New Concepts in Tree Planting" available from the Bartlett Tree Research Laboratories provides detailed planting recommendations.

MAINTAINING YOUNG TREES

Most transplants require two to four years to become established in the landscape. During this period, it is critical that adequate irrigation is provided when natural rainfall is insufficient for tree requirements. Periodic inspections to assess plant health and to identify and correct cultural and pest problems also are critical to survival.

Once the tree becomes established, it enters a phase of rapid growth. During this period, young trees may require routine fertilization, irrigation and mulch corrections to assure optimum growth. Periodic inspections for pests and other cultural problems will facilitate early detection and treatment before plant health is impacted.
Pruning of young trees is essential to provide strong branch structure for future



Relative ability of trees to tolerate and respond to environmental stress and maintenance treatments with age.

	Young	Mature	Declining
Relative size and complexity of plant	Low	High	High
Ratio of PSN* to non PSN tissue	High	Low	Low
Relative maintenance demand	Moderate	High	High
Mass: Energy ratio	1:100	1:1	1:0.5
Ability to respond to environmental change	High	Moderate	Low

* Photosynthetic

From Clark & Matheny (1)

growth. Pruning when trees are young can prevent costly problems later in the life of the plant. Primary considerations when pruning young trees include maintaining a strong central leader, selecting scaffold limbs with strong angles of attachment, maintaining adequate distances between major limbs and removing dead, dying conflicting branches.

MAINTAINING MATURE TREES

Maintaining a stable environment around mature trees is critical in delaying the transition from maturity to decline and death. Tree management programs should be proactive rather than reactionary. Treatments should be applied preventatively to maintain plant health rather than remedial treatments once decline begins.

Mature trees should be inspected at least once each year to evaluate plant health and identify any potentially hazardous conditions due to wood decay, root disorders, deadwood and other structural deficiencies. Inspection dates and findings should be documented in writing for liability reasons. Remedial treatment to correct hazardous conditions must be given highest priority in tree management programs.

<u>Pruning</u>: Pruning mature trees must be done judiciously. Severe pruning reduces the leaf surface area and creates numerous wounds, which creates an energy deficit. Pruning should be focused at removing dead, dying, diseased, broken and crossing/rubbing branches. When selective thinning is necessary to reduce wind resistance, this should be performed judiciously. No more than twenty percent of the live crown should be removed during any single operation.

Selective thinning of the crown should be concentrated on branch ends. Thinning the outer portion of the crown will improve light and air penetration and reduces the weight of that portion of the branch which is most prone to breakage. Many arborists are now thinning trees by stripping interior portions of the crown. This technique promotes growth at branch ends and reduces branch taper, which actually increases the frequency of limb failure during storms. Specifications for pruning require that at least one third of the branches should be left on the lower fifty per cent of a leader in order to encourage taper and reduce risk of breakage.

Topping trees creates a severe energy deficit by removing the leaf surface area and by creating numerous large, wounds which requires energy for compartmentalization. In addition to disfiguring the crown, topping is a common stress factor, which can predispose mature trees to decline, and initiates the mortality spiral. If trees survive topping, the resulting sprout growth is poorly attached to the parent limb and prone to failure during storms.

<u>Fertilization:</u> Urban soils typically are very disturbed and lack adequate organic matter. Nutrient stress, especially nitrogen deficiency is common on urban plants. In many areas soils are very alkaline which predisposes certain plants to micronutrient deficiency. Iron deficiency is quite prevalent on pin oak and white pine, while

manganese deficiency is frequently encountered on maple, sweetgum, and dogwood. These deficiencies inhibit chlorophyll production and reduce photosynthesis.

Preventing nutrient stress through periodic fertilization is an important consideration in managing mature trees. Fertilization is particularly important where trees must compete with turf for soil nutrients. Specific fertilization specifications should be based on soil and/or foliar analysis. Correcting micronutrient deficiencies on alkaline soils can be difficult and marginally successful.

Planting alkaline sites with species compatible to these soils will prevent needless expense and premature decline. Soil analysis to determine pH, soil type, organic matter content and nutrient levels must be done during the site planning process in order to select species which are compatible to local soil conditions.

Irrigation: During moisture stress from droughts or other factors, stomates in leaves naturally close to reduce water loss from transpiration. This response reduces water needs but inhibits photosynthesis. Trees survive droughts largely on stored reserves. Irrigation is important to prevent moisture stress during droughts. In most areas of the Eastern United States, trees demand one inch of irrigation water per week during the growing season when rainfall does not occur. This is equivalent to 700 gallons of water per thousand square feet of root zone. Irrigation water can be supplied gradually using a drip system or applied in one or two applications per week.

Pest Management: Insect pests and disease organisms can weaken trees by defoliation as well as stem and root damage. Pests should be managed using integrated pest management (IPM) principles. IPM is a system of periodically inspecting plants for pests and other plant health problems. When detected, pests are maintained below levels which impact plant health through cultural, biological and/or chemical treatments.

Root System Care: Root loss is the most common contributing factor to premature decline and death of urban trees. Root loss occurs from many activities including construction, compaction, and installation of underground utilities, sidewalk repair, and root disease pathogens. Competition with turf and excessive soil moisture from irrigation or grade changes also causes root loss or inhibits root development. Trees must be protected from construction activities during new site developments and from vehicular and pedestrian traffic.

Mulching trees is highly effective for improving the soil environment for root growth. Mulches moderate soil temperatures, conserve soil moisture, provide organic material and provide a buffer against compaction. Mulches in lieu of turf eliminate competition for water and nutrients between turf and trees.

Organic mulches such as wood chips, bark nuggets, leaves or pine straw provide more benefit than inorganic mulches. A two to four inch depth over the root zone of the plant is optimal. However, some benefit will be derived from smaller rings of mulch closer to the stem. Mulches should not accumulate against the stems of the plants.

Literature Cited

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3. Ossenbruggen, H.S. 1989. *Tree Energy Systems.* Journal of Arboriculture 15:53-58.