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Bartlett Tree Research Laboratories Technical Report

Managing Mature Trees

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Management of mature trees 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.

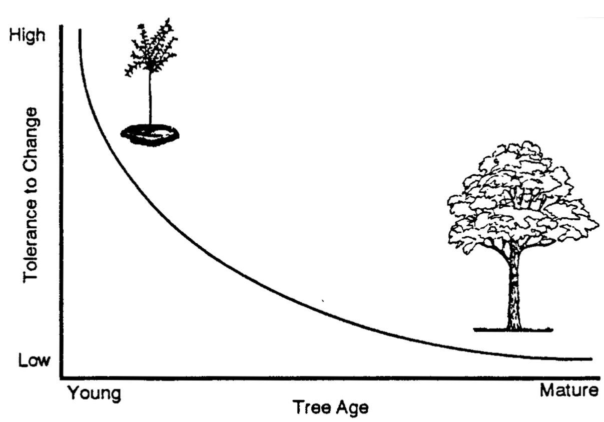
Energy to drive biological functions in trees is derived from sunlight. Chlorophyll in leaves captures energy from sunlight and stores it in chemical bonds in carbohydrates. This energy is used to support biological functions in a process called respiration. During respiration, high-energy-yielding bonds holding carbon, hydrogen and oxygen in carbohydrate molecules are broken, releasing energy. This energy fuels all biological activities, leaf development, growth, defense and flower and seed production.

Energy also is stored in reserve for "emergencies", i.e. periods of stress such as drought or defoliation by pests, when current energy production cannot meet demand. Growth, defense or both may suffer at the expense of maintaining existing tissues during these periods of stress.

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 decreases. 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 not as 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 causes, growth rate slows because energy reserves are utilized 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 are further reduced and decline begins.



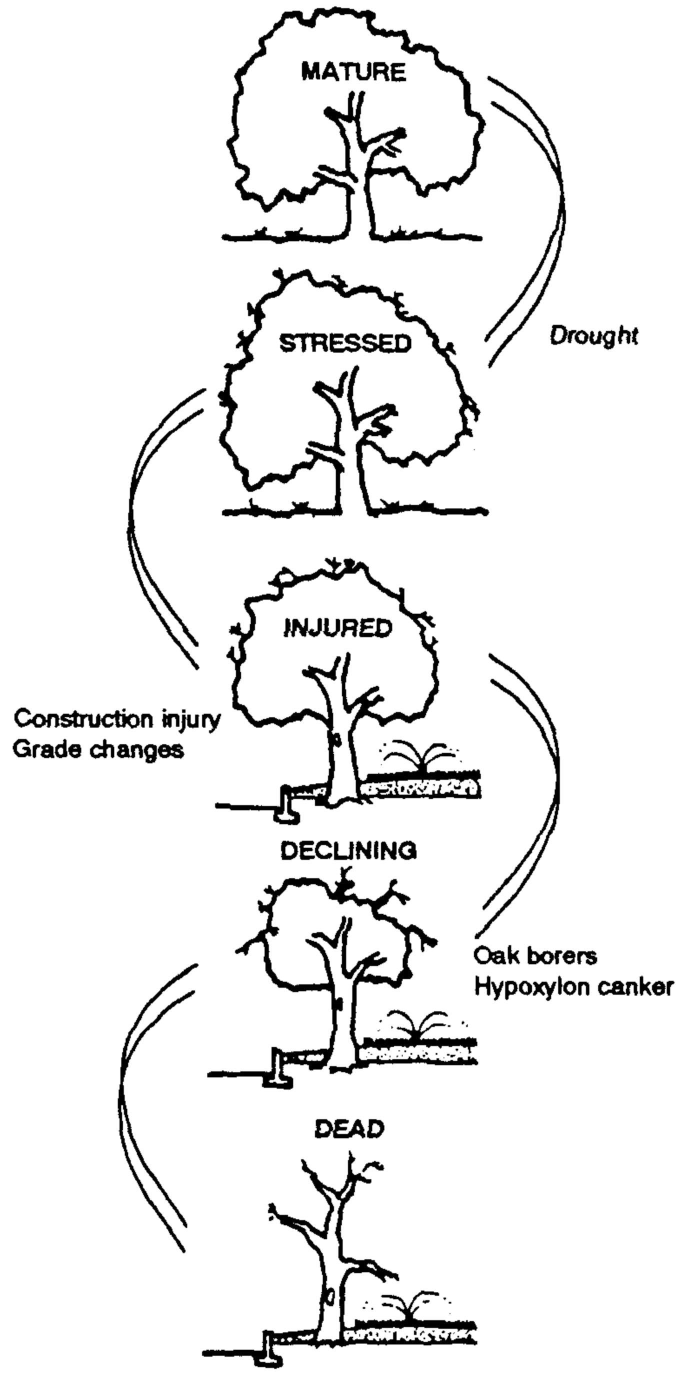
Relative stability of trees to tolerate and respond to environmental stress and maintenance treatments with age.

Comparative development of
young, mature, and declining trees

	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

From Clark, J. and Nelda Matheny. 1991. Management of Mature Trees. Journal of Arboriculture 17:173-184.

The declining tree has 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.



Typical mortality spiral for red oaks.

Management Considerations
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 reactive. Treatments should be applied preventively to maintain plant health rather than remedial once decline begins.

Planning
Maintaining a stable environment around trees begins with developing an initial site plan. Large growing species in confined spaces will decline prematurely. Limited water and nutrient availability creates energy deficits soon after planting. The average lifespan of an inner city tree growing curbside in a tree pit is seven years. Tall 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 the plant to decline.

Some tree species naturally decline and die at an early age. Fast growing species such as silver maple, poplar and willow generally have a shorter life span than slower growing trees. Fast growing trees generally allocate more energy to growth and less to defense. These trees are apt to be poor compartmentalizers and more prone to life threatening pest problems.

Matching species to site is essential for long-term tree survival. Selection considerations should include available root space, crown space, soil type, hardiness (adaptability to temperature extremes), life span and resistance or tolerance to pest problems.

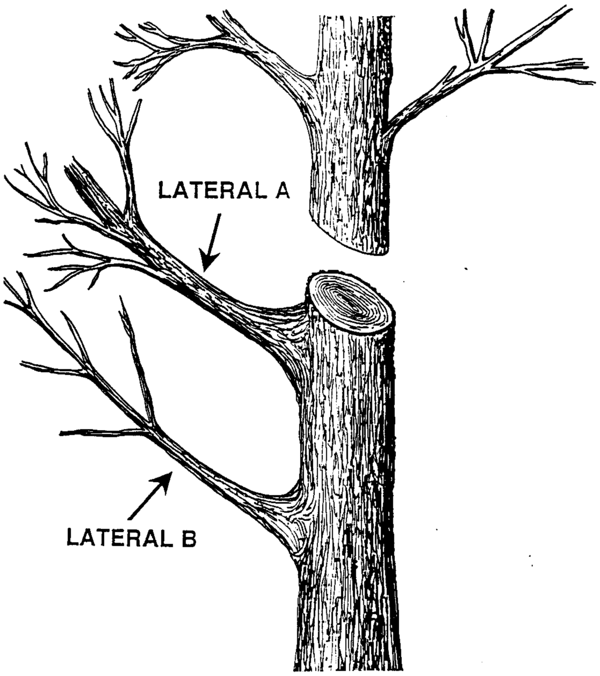
Inspections
Periodically inspecting mature trees for structural defects, including dead and broken limbs, cracks, split crotches, decay and root defects, is essential to prevent failures that could lead to personal injury or property damage. Inspections can also reveal early symptoms of stress, which may be corrected before irreversible decline occurs.

Tree structure and health inspections should be performed at least annually and after major storms. Inspections should be more frequent (such as monthly) in high use areas and for trees under stress. Inspection dates and findings should be documented in writing.

Maintenance Considerations
Properly performed cultural practices, including pruning, fertilization, pest management and root system protection, can increase longevity of mature trees. Improper techniques are common stress factors of urban trees, which cause premature decline.

Pruning
Pruning mature trees must be done judiciously. Severe pruning reduces leaf surface area and produces numerous wounds, which create an energy deficit. Pruning should be focused on 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 one-fourth of the live crown should be removed during any single operation.

When needed, 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. Some 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 half of the branches should be left on the lower two thirds of a leader in order to encourage taper and reduce risk of breakage.

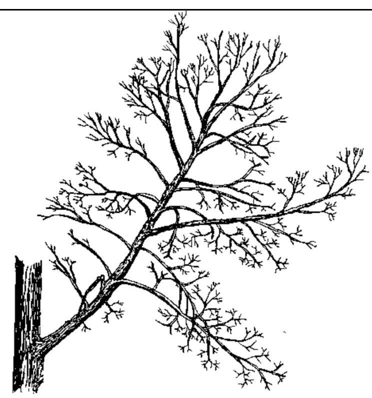
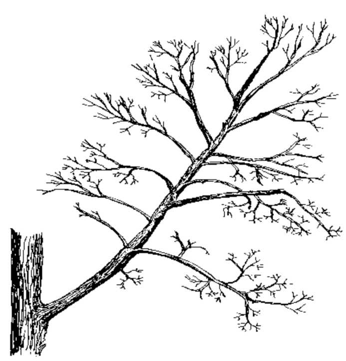
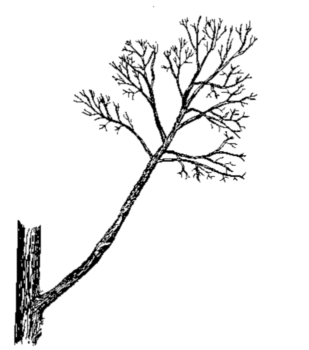


Lateral pruning

When crown reduction is performed, limbs should be cut back to laterals, which are large enough to assume dominance. This will minimize suckering, promote wound closure and reduce the risk of dieback. Avoid removing more than one-fourth of the leaf surface area during a single growing season.

Crown Reduction Pruning
Crown reduction pruning should be undertaken only when necessary to eliminate branches, which are interfering with buildings, traffic flow, utilities, security lights or other structures. Crown reduction pruning may also be to correct storm damage, compensate for structural defects or provide a more desirable shape. Crown reduction pruning should be considered as a necessity rather than a preferred maintenance option. Cabling and bracing may be an alternative to crown reduction pruning.

Pruning Declining Trees: A common practice in the past was to reduce crown size on declining trees. This was particularly common on trees declining from root loss. The concept was to concentrate the tree's energy into a smaller mass and to balance the root and crown systems. This tactic is seldom successful for the same reasons that topping is detrimental. Pruning should be confined to removal of dead, diseased and broken limbs of declining trees. Live branches should be left intact to maximize the energy-producing surface and limit wounding.

		
Before thinning	**Proper thinning**	**Improper thinning (lions-tailing)**

Fertilization
Urban soils typically are disturbed and lack adequate organic matter. Nutrient stress, especially nitrogen deficiency, is common in urban plants. Alkaline soils predispose certain plants to micronutrient deficiencies. Iron deficiency is quite prevalent on pin oak and pine, while manganese deficiency is

frequently encountered on maple, sweetgum and dogwood. These deficiencies inhibit chlorophyll production and reduce photosynthesis. Preventing nutrient stress by periodic supplemental fertilization is an important consideration in managing mature trees. Fertilization is particularly important where trees must compete with turf for soil nutrients. Fertilizer 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 such soils will prevent needless maintenance 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 root loss, stomates in leaves close naturally 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 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 or by causing stem and root damage, which impedes absorption and translocation of water and nutrients. Pests should be managed using integrated pest management (IPM) principles. IPM is a technique 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 inciting factor to premature decline and death of urban trees. It occurs from many causes, 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 cause root loss or inhibit root development.

Adequate space for root development must be provided during initial site planning to ensure that trees have sufficient soil volume to reach maturity. Where tree lawns are narrow, use species, which remain small at maturity. Protect existing trees from construction activities during new site development 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. Mulch in lieu of turf eliminates competition for water and nutrients between turf and trees. A two-tofour inch depth over the root zone is optimal. Some benefit will be derived from smaller rings of mulch closer to the stem. Mulches should not be allowed to accumulate against the stems of plants.

Literature Cited
1. Clark, J. and Nelda Matheny. 1991. Management of Mature Trees. Journal of Arboriculture 17:173-184.
2. Ossenbruggen, H.S. 1989. Tree Energy Systems. Journal of Arboriculture 15:53-58