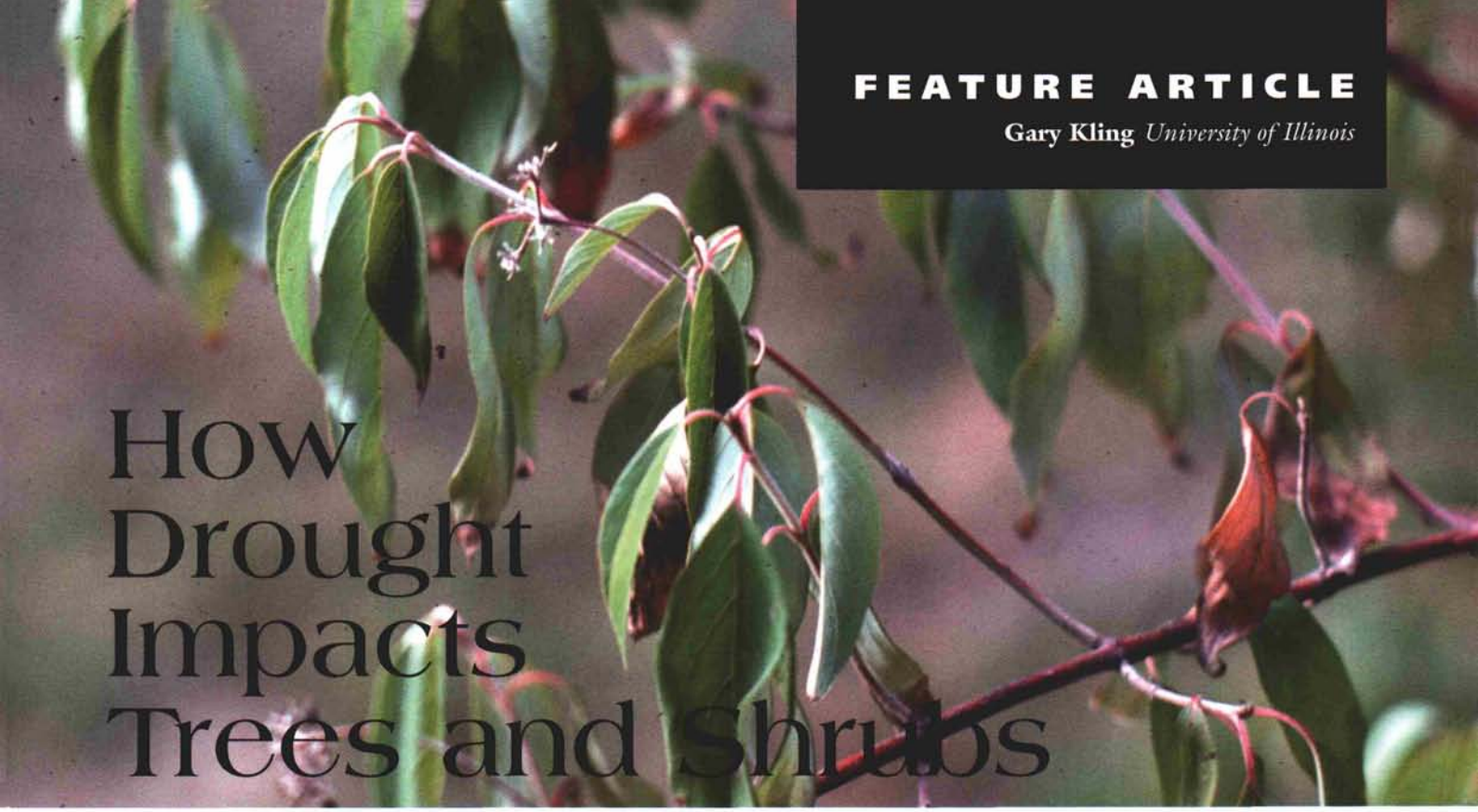

FEATURE ARTICLE

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How Drought Impacts Trees and Shrubs

"The drought is over, thank goodness we can forget about that and move on to other things."

However, if you are a tree or shrub, the effects from the drought of 2005 are far from over. While recent rains have provided relief, the effects from this summer's drought will be with us for the next few years. The stresses imposed upon plants will affect winter damage, shoot growth for next season, flowering and fruiting for next season and may lead to the development of several drought-related disease and insect problems. Long-term effects vary with the establishment of the specimen, the species, the amount and pattern of subsequent precipitation, fertility levels, the severity and the timing of the drought, and additional stresses placed on the plant.

For most plants in most situations, with the exception of old specimens, the detrimental effects of drought will likely manifest themselves over a two-to-three-year period.

Before overreacting, remember that summer drought is an occasional but predictable fact of life. Drought is a normal occurrence that plants in cultivated situations as well as those in native areas will experience many times in their lives. Plants also have some ways of using the initial stages of a drought to better prepare themselves for more severe drought. Moderately stressed trees make more efficient use of water and nutrients and develop a more extensive root system. Stressed plants also increase their carbohydrate storage and levels of defense chemicals needed to fight off insect and disease problems.

Although drought may be normal, that does not lessen its impact on our landscape plants. Long-term damage, especially to large old specimen trees, can result from a serious drought. While we might easily see the effects over a season, a long-term decline in vigor can put a prized old tree in a steady spiral of decline, making it more susceptible to additional stresses that might otherwise have had a negligible effect. An example of long-term effect can be seen in the decline of the Black Forest in Germany. Some of that deterioration was attributed to a severe drought 30 years previous. For most plants in most situations, with the exception of old specimens, the detrimental effects of drought will likely manifest themselves over a two-to-three-year period.

Immediate and Short-Term Effects

Immediate effects of drought include leaf wilting in the initial stages followed by leaf scorch or marginal browning and leaf drop as the stress

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continues. Drought stress during leaf expansion will decrease the size of leaves as water is essential to provide the turgor pressure needed to expand cells. A prolonged drought can result in significant damage to the roots as well as the shoots and cause branch dieback or even plant death. As in so many things, timing is important in determining the effects of the drought. Early-season droughts tend to be more damaging than late-season droughts. Newly emerged leaves and shoots are particularly susceptible to water shortages. The level of injury is greatly increased if the plants are not fully established. To be fully established might require approximately two years for most shrubs and two to four years for trees, depending upon their transplantability.

Although drought affects the whole plant, the injury to leaves is what is most obvious. Leaves produced under drought conditions are smaller and more highly dissected to reduce transpiration. With this year's drought, leaves on birch and poplars fell earlier and many other species showed leaf curl and browning of their leaf margins. In a drought, many trees will also show early fall coloration, a sign of stress on the plant. Because water is essential to the uptake of nutrients from the soil, this summer's drought produced leaf yellowing on some species—a sign of nutrient deficiency. While water stress adversely affects leaf growth, plants find ways to use that stress to their advantage. Leaves produced during a drought are better able to handle further water stress than those produced under lush growing conditions. As a plant approaches winter, its drought tolerance increases with cold tolerance and then decreases in spring.

Drought injury frequently induces heavy flowering and fruiting in the same or subsequent years and thus leaves less energy for shoot growth and production of proteins essential to a wide variety of plant functions. Some of our flowering shrubs can be expected to flower and fruit heavier next year in an effort to reproduce before any further stress causes death.

Although drought effects are most easily seen on leaves, plant roots suffer as well. Shallow-rooted trees such as flowering dogwood and sugar maple are much more sensitive than more deeply rooted trees such as black walnut and many of the oaks. To compensate for the shortage of available water, plants under moderate stress produce proportionally more root growth than shoot growth. Roots of woody plants do not go dormant and continue to grow until nearly frozen. Because physiological processes continue in roots throughout the year, adequate moisture must be available at all times to prevent injury. Therefore, be sure your landscape plants have an adequate but not excessive amount of moisture before the ground freezes.

Trees in parking lots or those surrounded by concrete should receive special attention to avoid further water stress.

Internal or physiological effects of drought help to explain what we see on the outside. Water stress reduces cell enlargement more than cell division, thus explaining the reduction in leaf size attributed to drought. Growth is limited by even mild water deficits, producing a decrease in leaf number and size and reduced shoot length. Photosynthesis continues to function relatively unhindered under slight to moderate stress, allowing plants to handle the occasional drought with minimal effects. Severe water shortage, however, damages the photosynthetic machinery responsible for providing energy to all plant processes. Respiration, the process through which plants convert stored energy to usable forms, is also inhibited under severe stress. Synthesis of proteins, the building blocks of life, is inhibited by severe drought. When water stress becomes severe, plant survival depends upon the degree of dehydration that the protoplasm in the cells can endure without undergoing irreversible injury.

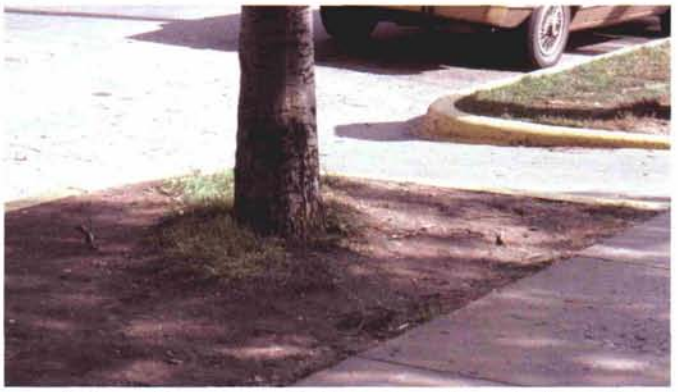
Plant fertility also plays a role in determining the effects of a drought. Well-fertilized trees and shrubs are more susceptible to damage from a drought. Most fertilizer applications contain nitrogen to stimulate shoot growth. The shoot growth stimulated by nitrogen fertilizer can come at the expense of root growth. Rapidly growing trees are thus more susceptible to drought than slower-growing specimens. Well-fertilized trees will typically need more irrigation and pesticide sprays than plants that are under moderate to low levels of fertility. Unless trees are showing nutrient-deficiency symptoms, fertilizing trees increases shoot growth without increasing photosynthesis. If you fertilize following a drought, use one with low nitrogen and higher phosphorous and potassium to rebuild root systems.

Drought can be a major contributing factor to insect and disease problems. Water stress increases plant susceptibility to wood-boring insects and canker diseases. Following a drought, Cytospora canker becomes more likely on maples, mountain ash, poplars, spruce and willows. Nectria canker will be more likely on ash, birch, black walnut, crabapple, elm, lindens, locust, maples and oaks. Botryosphaeria canker can affect American sweetgum, beech, black tupelo, crabapple, flowering cherries, flowering dogwoods, hickory, horsechestnut, London planetree, redbud, willow and many others. The canker diseases are especially likely on newly transplanted specimens of these and many other species. Look for brown sunken oval patches on plant stems. Once a canker grows to surround the stem, the branch above that point dies. Prune out and destroy infected branches in dry weather and

avoid further stresses on the plant. Drought will also increase the development of some vascular wilt diseases. Verticillium wilt, a fungal disease with a host range in excess of 300 species, is more likely to show up following drought stress. Aphids and spider mites, although less serious than the above problems, are often seen to greatly increase in number in a drought season due to the simultaneous increase in temperatures that often accompanies drought.

An Ounce of Prevention . . .

Prevention is one of the best weapons a manager has to combat drought injury. Choosing native plants that are adapted to local water cycles is one of the most effective strategies. Obtaining plants propagated from specimens that were growing within 50 or 100 miles of your site will ensure the best adaptability. At the same time, since we have many sites that are so drastically modified from their native condition, do not fail to look at non-native species that might be better adapted to some of these highly disturbed sites. Select plants from dry environments that will not require frequent supplemental irrigation to keep them looking good. Species such as spruce, fir and Canadian hemlock are native to cool moist areas and require frequent irrigation in a drought. Each species has its own level of drought tolerance depending upon its adaptational features. For further information on plant selection and drought-tolerant species, call upon your local extension agent or visit my Web site at www.woodyplants.nres.uiuc.edu.



Soil aeration and watering will reduce the impact of drought stress on trees subjected to soil compaction and reflected heat from the street.

As I look into my crystal ball, I foresee an increase in drought episodes attributable to a changing climate and at the same time, more frequent watering restrictions for landscapes. Selection of species able to survive with reduced water inputs is likely to be essential in future landscapes. The use of organic mulches around trees and shrubs can do a lot to reduce the effects of drought and to modify the effects of high temperatures that often accompany droughts. A two-to-four-inch layer of shredded bark, wood chips or other organic material can greatly reduce water loss and provide a more uniform moisture supply

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TABLE 1.
Selected List of Drought-Tolerant Species[1]

Trees	Common name	Native to U.S.
Acer campestre	Hedge Maple	N
Acer ginnala	Amur Maple	N
Albizia julibrissin	Mimosa	N
Castanea mollissima	Chinese Chestnut	N
Catalpa speciosa	Northern Catalpa	Y
Carya ovata	Shagbark Hickory	Y
Celtis occidentalis	Common Hackberry	Y
Corylus colurna	Turkish Filbert	N
Crataegus spp.	Hawthorns	Y
Eucommia ulmoides	Hardy Rubbertree	N
Fraxinus pennsylvanica	Green Ash	Y
Ginkgo biloba	Ginkgo	N
Gleditsia triacanthos inermis	Thornless Common Honeylocust	Y
Gymnocladus dioica	Kentucky Coffeetree	Y
Juglans nigra	Black Walnut	Y
Juniperus virginiana	Eastern Redcedar	Y
Maclura pomifera	Osage-orange	Y
Phellodendron amurense	Amur Corktree	N
Pinus flexilis	Limber Pine	Y
Pinus mugo	Mugo Pine	N
Pinus nigra	Austrian Pine	N
Pinus ponderosa	Ponderosa Pine	Y
Pinus sylvestris	Scot's Pine	N
Populus deltoides	Eastern Cottonwood	Y
Pseudotsuga menziesii	Douglas-fir	Y
Quercus macrocarpa	Bur Oak	Y
Quercus montana	Chestnut Oak	Y
Quercus muehlenbergii	Chinkapin Oak	Y
Robinia pseudoacacia	Black Locust	Y
Shepherdia argentea	Silver Buffaloberry	Y
Sophora japonica	Japanese Pagodatree	N

Shrubs	Common name	Native to U.S.
Acanthopanax sieboldianus	Five-leaf Aralia	N
Ceanothus americanus	New Jersey Tea	Y
Chaenomeles spp.	Flowering Quince	N
Comptonia peregrina	Sweetfern	Y
Cornus racemosa	Gray Dogwood	Y
Cornus sanguinea	Bloodtwig Dogwood	N
Corylus spp.	Filberts	Y/N
Cotinus spp.	Smokebushes	Y/N
Diervilla spp.	Bushhoneysuckles	Y
Hippophae rhamnoides	Common Sea Buckthorn	N
Hypericum spp.	St. Johnsworts	Y
Juniperus spp.	Junipers	Y
Kolkwitzia amabilis	Beautybush	N
Lonicera spp.	Honeysuckles	N
Fallopia japonica	Fleeceflower	N
Physocarpus opulifolius	Common Ninebark	Y
Prunus spp.	Flowering Plums and Cherries	Y/N
Rhus spp.	Sumacs	Y
Ribes spp.	Currants	Y/N
Rosa rugosa	Rugosa Rose	N
Spiraea spp.	Spireas	N
Symphoricarpos orbiculatus	Indiancurrant Coralberry	Y
Viburnum prunifolium	Blackhaw Viburnum	Y
Yucca spp.	Yucca or Adam's Needles	Y

1 Plants included on this list are moderately drought-tolerant. Supplemental water will be required for many of these species under extreme conditions.

to the plant. Avoid mulching too deeply as this reduces soil aeration and encourages plants to develop roots in the mulch area, making the plants more susceptible to drought if the mulch layer is not maintained. The mulch should not be more than 1-2″ deep around the trunks of trees to avoid encouraging fungal attacks through the bark. The mulch should ideally be in place well in advance of a drought to conserve the normal rainfall or irrigation water. The mulch should remain in place through the winter to moderate the effects of severe winter temperatures. Depending upon the breakdown rate of the mulch material, it will need to be replenished at least once a year. Rock mulches have few beneficial effects and several negative ones.

As you select new plants for your landscapes, be sure to purchase them from quality nurseries. Plants produced in quality nurseries often have superior root systems as a result of root pruning in the production process and planting at the proper depth. Trees should have their first branch roots just below the surface. Although planting too deeply may give the plant some initial benefit in terms of soil-moisture availability, the long-term health of the root system will be greatly diminished in the lower oxygen levels found at lower depths. Subjecting plants to slight to moderate water stress a few weeks prior to planting helps to "harden" the plant and increase its transplant survival.

Checklist for the Conscientious Manager

There are also a number of things that a conscientious manager does following a drought. Make a point of remembering which plants were particularly stressed this past season and watch them closely in the next few seasons. Provide those plants water during small future water deficits and consider some shoot pruning to balance the root system if the stress was particularly hard on the plant. Watch these plants for signs of canker and vascular diseases as well as boring insects. These problems are likely to build in the following years, especially in the presence of additional stresses. Also watch plants for excessive moisture levels following a drought. There are many times when a drought is followed by long periods of exceptionally heavy precipitation in the following season. The resulting water-logging of the soil for many weeks can further damage plant roots. Anticipate those conditions by providing adequate drainage for key specimens and avoid overwatering to compensate for drought injury. Most trees and shrubs in the landscape should not be watered more frequently than once a week. If stressed plants were not previously mulched, consider doing it now. A mulch layer will reduce root injury if we get a very cold winter with little precipitation. Be sure to avoid further injury to already stressed plants through soil compaction or bark injury. The addition of another stress may be sufficient to tip the balance of survival.