

# Stress and Decline in Woody Plants

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Woody plant stress has many causes that might ultimately lead to plant decline. Tree and shrub degeneration is often referred to as a “complex,” meaning the condition is usually caused by multiple factors. Typically, one or more primary stresses cause deterioration of plant health, followed by secondary pathogens and/or insects that further decline or destroy plants. Determining causes of decline requires careful examination of plants and growing sites, as well as knowledge of site history. Nevertheless, diagnoses may be difficult, as the original cause(s) of plant stress may be obscure or no longer present.

Affected woody plants may survive over a long period of time (in some cases, decades) in a gradual state of decline. Alternatively, plants may rapidly decline over one or two years or they may appear to die suddenly. Sudden death is most common when already weakened woody plants are subjected to a particularly severe environmental stress, such as excessive heat or drought.

Some of the most common plant stresses are addressed in this publication. A wider range of possible causes of plant stress and decline should be considered during evaluation of woody plant material.

**Figure 1.** Norway spruce on the left suffers from environmental stress, while the specimen on the right is not affected.



**Figure 2.** Verticillium wilt, shown here on catalpa, is a vascular disease that causes die-back in a broad range of hosts.



## Plant Ecology and Physiology

Each part of a woody plant's anatomy performs unique functions, all of which are necessary for healthy growth. Interruptions in any of these functions may lead to stress and ultimately, to plant decline (Figure 1).

### Leaves

Photosynthesis, or food production, takes place in leaves. The leaves utilize water and nutrients taken up by roots, combine them with carbon dioxide from the air and energy from the sun, and produce carbohydrates that fuel entire plant systems. When an outside factor interferes with normal photosynthesis, plants produce less food and have fewer energy reserves.

### Trunks

Woody plant trunks physically support branches and leaves, conduct nutrients and water from roots to leaves, and transport carbohydrates down to roots. Transport systems, called vascular tissue

(including xylem and phloem), move these vital products from source (where they are produced) to sink (where they are stored or utilized). Damage to vascular tissue inhibits water, nutrient, and carbohydrate transport, resulting in deficiencies that equate to starvation.

### Roots

Roots support plants, store energy, and absorb water and nutrients from soil. The majority of tree and shrub roots are within the top 3 feet of soil (deeper in sandy soils), and more than 90 percent of a woody plant's small feeder roots are usually located in the top 12 inches of soil. Roots extend outward from trunks much farther than branches or driplines. In fact, roots often extend 1½ to 2 times the spread of woody plant canopies. Thus, root damage caused by grade change (suffocation), cultivation (physical damage), or compaction (physical barrier) affects uptake of water and nutrients.



**Figure 3.** Scorching of leaf margins is often caused by restricted water uptake (e.g. drought, root damage, cankers, etc.).



**Figure 4.** Severely declining or dying trees may re-sprout from roots, even though primary trunk is dead.

## Common Signs and Symptoms of Stress and Decline

When plants are stressed by biotic or abiotic factors, they begin to decline. During the early stages of decline or when symptoms appear gradually, it may be possible to alter conditions and improve plant health. Frequent observations, including routine scouting, are key to identifying symptoms and managing stress.

Symptoms can include:

- Thinning canopy
- Dead limbs, dieback (Figure 2)
- Lichen growth on branches and trunks
- Off-color leaves (pale green or yellow in summer)
- Small or stunted leaves or shoots
- Stunted branches, short internodes
- Leaf scorch, brown leaf margins (Figure 3)
- Premature leaf drop
- Premature fall coloration (late summer)
- Water sprouts or suckers growing from lateral branches or bases of trunks (Figure 4)
- Presence of insects (egg masses, visible insects, frass) (Figure 5), increased insect damage
- Presence of disease and/or signs of disease-causing pathogens (mushrooms, conks, bracket fungi) (Figure 6)

## Causes of Plant Stress

Plant stress may be caused by various external factors that affect nutrient availability, gas exchange, or other critical life processes. Various levels of one or more of these stresses can affect severity of plant decline.

### Poor Plant Selection for the Location

Ornamental plants thrive best in locations similar to the soil and climatic conditions of their natural habitats. Plants placed in environments unlike their native conditions are more likely to become stressed. For example, wetland plants will not perform well in sandy upland soils, and shade plants often suffer in sunny locations.

### Physical Constraints

Mature sizes of trees or shrubs must be considered before planting. Crown spread, plant height, trunk diameter, and root spread are all important components of plant size. In open spaces, woody plant roots may expand twice as far as the expected mature crown spread. However, building foundations, paved roadways, sidewalks, and other physical barriers inhibit expansion of root systems, thereby reducing availability of water and nutrients.



**Figure 5.** Boring insects cause branch dieback, but they may be difficult to detect without removing bark.



**Figure 6.** Mushrooms and conks indicate colonization and decay by wood-rotting fungi.

### Improper Planting Practices

New plantings require proper installation so that they can become well established. Young plants should be set so that the root-trunk interface is at ground level and root flare is visible. Roots set too deeply suffer from oxygen deprivation and trunk rot. Planting holes should be dug twice as wide as root balls to loosen surrounding soil, and fill should be the same soil that was removed from the planting hole. See *Transplant Shock: Disease or Cultural Problem?* (PPFS-W-OR-19) for information on proper transplanting methods.

Newly installed trees and shrubs should have healthy root systems that are evenly distributed and are not encircling or rootbound. Upon planting, roots should be spread evenly across planting holes without curling or restriction. Lateral roots that encircle tree trunks or intertwine with other main lateral roots (girdling roots) cause restriction of water and nutrient flow. Often these symptoms are not evident until plants are well-established (20 or more years old). Girdling roots may be partially exposed at soil surfaces, forming a noose around trees. In other cases, girdling roots may be 6 to 12 inches deep.

### Poor Soil Conditions

Planting sites for trees and shrubs should have a minimum of 3 feet of permeable (deep) soil that does not have a hardpan or other root-restrictive layer. These deep soils allow tree roots to grow easily and permit water movement and gas exchange.

**Shallow soils**, or those with restrictive layers, inhibit root growth as roots approach rocky, clay, or compacted layers. In contrast to deep soils, shallow soils have less “water-holding capacity,” as soil can only retain certain amounts of water. Thus, water runoff or puddling increases with shallow soil during wet conditions, and drought conditions result during dry seasons. Shallow soils can result from historical erosion (typically associated with greater slopes), removal of topsoil during construction, rocky soils, and/or naturally occurring restrictive layers (in Western Kentucky, fragipans). As a result, roots remain close to soil surfaces and are vulnerable to drought, heat, and nutrient deficiencies. Additionally, shallow-rooted trees are poorly anchored and are at risk to blow over during strong winds. Refer to *Evaluating Land Resource Potentials in Kentucky* (in press) for additional information.

**Compacted soils** affect root growth and development. For optimal plant growth, soil must be loose enough to provide spaces (soil pores) for air and water. Compaction reduces size and number of these spaces. Primary causes of soil compaction include foot traffic from people and animals (pets, livestock) and vehicular traffic (cars, equipment). Construction projects also cause compaction. For more information, refer to *Trees and Compacted Soils* (HO-93).

**Poorly drained soils** hold excess amounts of water (Figure 7) and deprive roots of oxygen. Surface drainage is often easy to monitor, while digging or probing is required to analyze internal drainage problems (heavy or clay soils, compacted subsoil). Red or brown soils indicate good drainage, while soils that are gray or dull-colored represent poor internal drainage. Drainage mottles (spots or blotches of different colors within the “normal” soil color) also indicate poor drainage. Excess water buildup occurs in poorly drained soils during periods of heavy rainfall or improper irrigation practices. Water may also drain away slowly. Many root rot pathogens favor wet soils, so disease is another problem in poorly drained soils. For additional information, refer to the section on diseases, under Biological Stresses, below, as well as the fact sheet entitled *Wet Feet in the Landscape* (PPFS-OR-W-04).

**Dry soils** do not hold adequate moisture for plant roots. Rocky or sandy soils and steep slopes are the most common causes of dry soil conditions, as they drain quickly and have low water-holding capacity. Shallow soils also have a lower water-holding capacity, thereby contributing to drought stress more readily. Competition with other plants, including landscape plants and turfgrass, can cause soils to dry out more readily. Dry soil conditions are especially detrimental to newly planted trees and shrubs (less than 5 years old); this symptom is called transplant shock (see *Transplant Shock: Disease or Cultural Problem?* PPFS-OR-W-19). See also *How Dry Seasons Affect Landscape Plants* (ID-89) for more information on plant care during dry seasons.

**Low soil fertility** leads to nutrient deficiency in plants. Kentucky soils are rarely deficient in nutrients required by woody trees and shrubs. However, a soil test is required to determine whether fertilization is required. Nursery and container-grown plants are more prone to nutrient deficiencies and should be monitored regularly.



**Figure 7.** Proper planting depth and good soil drainage prevent puddling and “wet feet.”

More often, improper soil pH (too high or too low) may reduce availability of nutrients to plants. A common example of pH-induced deficiency is iron chlorosis, also referred to as lime-induced chlorosis. This condition occurs where soil pH is neutral or alkaline (7.0 or above), especially where acid-loving plants are being grown. For more detailed information on iron chlorosis and its treatment, see *Iron Deficiency of Landscape Plants* (ID-84).

**Excess nutrients**, or over-fertilization, cause nutrient toxicities that are detrimental to plants. Nutrients that do not move readily through soils often build up to high levels if they are not properly monitored. For example, aluminum toxicity is common in soils where aluminum sulfate is used to lower pH. In contrast, common nutrients, such as nitrogen, move readily through soils but “burn” plant roots if applied at high rates. Thus, soil tests should be the basis for all fertilizer applications.



**Figure 8.** Sunscald often occurs on southern or southwestern sides of tree trunks during winter and early spring.



**Figure 9.** Mechanical damage caused by mowers and string trimmers are common causes of trunk damage.

### Climatic Stresses

**Cold temperatures** may be detrimental to plants that are not properly acclimated to Kentucky conditions, but they are often not harmful to dormant plants, native plants, or cold-hardy species. Sudden changes in temperatures during spring and fall are most common causes for freeze damage. For example, dramatic temperature drops after a warm autumn season are capable of killing tissue that has not properly “hardened-off.” Excessive nitrogen fertility, including fertilization later than mid-season, delays this hardening-off period.

Also, late spring freezes may damage tender new growth. Prolonged cold winds on north or northwest sides of hills or buildings, however, can cause tender plants to dry out any time during winter months (see *Leaf Scorch and Winter Drying of Woody Plants*, PPFS-OR-W-17).

**High temperatures** damage plants that are improperly acclimated to sunny areas. Young plants become “shocked” when moved from protected nursery conditions to open landscapes. Heat reflection from pavement or south-facing walls may create microclimates that result in unusually high temperatures. Heat damage can also occur during winter. Sunscald (Figure 8) or frost crack is caused by fluctuations in day/night temperatures during winter and early spring. Tender bark, especially those from thin-barked trees like maple and apple, may become scalded or split on south and southwest sides of trunks.

**Drought** conditions are most severe in young trees and new transplants (less than 5 years) (see *Transplant Shock: Disease or Cultural Problem?* PPFS-OR-W-19). Severe and/or prolonged droughts, as well as subsequent drought events, may affect established and drought-tolerant plants, as well. As a rule of thumb, most woody plants require 1 to 1½ inches of rainfall or supplemental water per week. Plant species and site conditions, however, determine specific requirements. Evapotranspiration models may provide growers and gardeners with more precise estimates of water loss (see UK Ag Weather Center Irrigation Manager Web site). This information can be used to determine severity of drought and need for supplemental irrigation. Once plants are damaged by drought, they may continue to show symptoms of decline for several years.

**Heavy rainfall** and excessive moisture result in waterlogged soil (Figure 7). Large amounts of soil water prevent air exchange in soil, resulting in suffocation and death of roots. Many root rot pathogens favor high soil moisture. (See “Poorly Drained Soils” in the Poor Soil Conditions section, above.)

**Extreme fluctuations in weather conditions**, such as heavy rains following a drought, or extreme cold after a period of warmer temperatures, can initiate plant stress. Leaves may wilt or scorch and defoliation may result.



**Figure 10.** Grade changes from construction projects result in reduced soil-air exchange.



**Figure 11.** Damage to roots leads to reduced water uptake and exposes roots to invasive pathogens and insects.

### Physical Injury

**Improper pruning** results in slow formation or failure of woody plants to develop callus tissue. Open wounds that do not callus serve as entry points for wood decay fungi. These fungal pathogens cause rot of heartwood or sapwood. Excessive pruning (more than 25 percent of canopies removed) results in reduction of photosynthesis and thereby reduced carbohydrate (food) production. For more information on proper pruning methods, refer to the publications *Pruning Landscape Shrubs* (HO-59) and *Pruning Landscape Trees* (HO-45).

**Mechanical wounds**, or injuries that cut into plant bark, may girdle trunks and inhibit nutrient and water uptake. Often, these wounds fail to callus and provide potential entry sites for insects and disease-causing organisms. Lawn mowers or weed trimmers are the primary culprits of mechanical wounds (Figure 9). For more information, refer to *Wounds and Wood Decay of Trees* (PPFS-OR-W-01).

**Grade change and construction** can damage plant roots (Figure 10). Addition of soil around root zones hinders soil-air exchange. New flower bed installations and foundations for new building projects are common causes for grade changes. A good indicator of excess fill soil is the lack of a normal buttress flare, the point in which trunks merge with roots and create a horizontal expansion of woody tissue. On the other hand, digging and excavating physically damages roots (Figure 11). Severed roots result in reduced water and nutrient uptake to plants, while exposed roots dry out and die from exposure. Construction projects, paving, and excavating also compact soil and suffocate roots by reducing soil air exchange.



**Figure 12.** Cankers, such as this necrotic canker on beech, girdle branches and restrict transport of water and nutrients.

### Biological Stresses

Woody plants are susceptible to numerous insect, disease, and other pest problems. These biological stresses can be a primary initiator of decline, making plants more susceptible to invasion or infection by pathogens and insects.

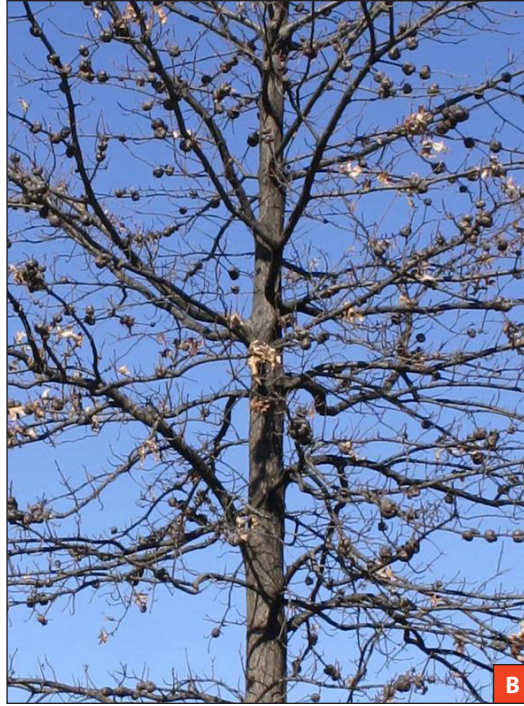
**Diseases** are caused by pathogens that can infect leaves, trunks/branches, or roots. Leaf spots and other foliar diseases cause reduction of photosynthesis. Resulting defoliation causes additional stress, and repeated defoliation events may eventually kill plants. Canker fungi infect woody plant parts, girdling and killing branches and trunks (Figure 12). These diseases usually spread gradually, causing dieback and other symptoms of decline. Vascular wilt diseases (Figure 2) are caused by pathogens that infect internal vascular systems. Affected xylem and phloem tissue is then unable to properly transport critical water and nutrients to branches and shoots. Dieback (Figure 2) and scorch symptoms (Figure 3) often occur during hot dry summer months due to this lack of water uptake. Root and butt rot diseases usually infect through root tips and decompose root tissue.

Most root rot pathogens favor high soil moisture. Some root pathogens spread to collars and into heartwood. External decline often occurs during hot summer months when water requirements are highest.

**Insects and mites** damage plants as they consume plant tissue or remove sap. Some transmit pathogens. Caterpillars and beetles can defoliate plants; tunnel into stems, branches, or leaves; or kill new shoots. A few species attack roots. Some bark beetles carry pathogenic fungi that hasten the death of stressed trees.

Sap feeding mites and insects, such as aphids, leafhoppers, and scales, are capable of causing wilting, yellowing, abnormal growth, or bronzing of leaves. Some aphids and soft scales produce large volumes of sugary liquid waste (honeydew) that support growth of sooty mold, which is attractive to foraging bees and wasps. Some species of leafhoppers and treehoppers spread diseases, such as bacterial leaf scorch of oak, while aphids may carry viruses. Chemicals produced by tiny wasps, along with some sap feeders, maggots, and mites can stimulate gall production. Often, galls





**Figure 13.** Horned oak galls (a) can induce stress and, in large numbers, cause dieback (b).

are simply aesthetic issues; however, wasp-induced horned oak gall (Figure 13) and gouty oak gall cause branch dieback.

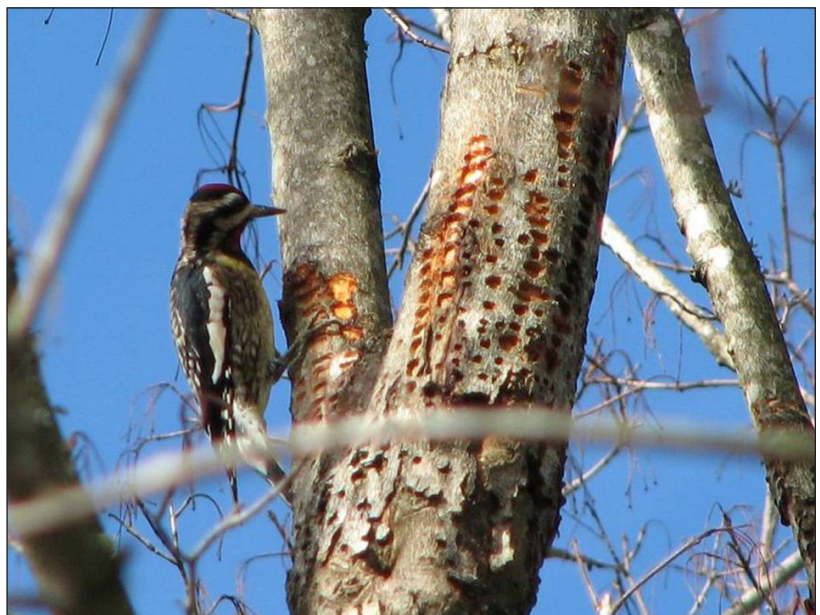
**Wildlife** can injure or kill woody plants under certain conditions. Sapsuckers (Figure 14) and woodpeckers bore holes in search for insects or nest sites. Mammals, such as voles, squirrels, rabbits, or beavers feed on roots, stems, and trunks, resulting in girdling. Deer that feed on leaves, twigs, buds, or shoots, and male deer that rub antlers on trees during “rut” will damage large portions of trunks and branches.

### Chemical Stresses

**Salt** and other deicers, when applied to sidewalks, parking lots, and roads, leaches into soils, changing soil pH and damaging roots. Salt spray from passing cars can float like fog for up to 100 yards, killing or damaging stems and buds on nearby dormant plants. Evergreens are more susceptible to salt injury than broadleaved plants (Figure 15).

**Excessive fertilizer** may cause toxicities (see discussion under Poor Soil Conditions, above). Often, Kentucky soils do not need regular applications of fertilizers. Soil tests can help prevent over-application of fertilizer or other amendments. If applied, broadcast over entire root zones because fertilizer applied to localized spots (drill application) may kill or “burn” surrounding roots.

**Herbicides** may be absorbed through roots or leaves. Granular and liquid lawn herbicides can be absorbed through tree roots and cause plant stress or death. Applications of turf herbicides commonly affect nearby trees that have roots extending onto lawns or where herbicides run into landscape beds. Symptoms include disfigured shoots, defoliation, dieback, and stunting. Herbicide spray drift may cause similar symptoms as



**Figure 14.** Sapsuckers drill holes in trees and then return to drink the sap and feed on trapped insects.



**Figure 15.** De-icing salts cause plants to freeze more easily; these salts move into plant beds via piled snow, and by drift or splash.

those of weed-killers absorbed by roots, but may also include leaf spots and leaf “burn.” Refer to *Weed Control for Kentucky Home Lawns* (AGR-208) for more information on herbicide selection.

### Managing Plant Stress

Prevention is the best way to avoid stress injury to trees and shrubs. Maintain vigorous plants by planting species that are adapted to Kentucky’s climate, avoiding physical injury to bark and roots, watering during dry spells, protecting trees during construction, and following other good cultural practices.

Once a plant is subjected to stressful conditions, begin by attempting to reverse adverse growing conditions (e.g., compaction or grade change). The following recommendations will help improve and maintain plant health.

#### Start with Healthy Plant Material

Healthy plant material that is free from physical injury, insect or disease damage, and nutrient deficiencies will establish more easily and more rapidly. Unhealthy plants are also more susceptible to secondary pests and problems.

#### Keep Trees and Shrubs Adequately Watered during Dry Periods

Irrigate woody plant material with the equivalent of 1 to 1½ inches of rainfall per week (if no rainfall event occurs) during the growing season. This amount is often sufficient for plant health, although plant age, plant species, and site conditions may dictate otherwise. Because tree roots

extend beyond driplines, irrigation should, as well. To avoid runoff, a slow-application method of watering, such as use of micro-irrigation (“drip irrigation”) or soaker hoses, is recommended. Plants should be watered at time of installation, and drought stress should be avoided until plants are well-established (3 to 5 years after planting).

#### Apply Mulch

Mulch protects root systems from moisture loss, temperature fluctuations, and weed competition, and provides protection from lawn equipment. A 2- to 3-inch deep layer of organic material (e.g. compost, woodchips, or sawdust) is recommended to extend across as much of root systems as possible (beyond driplines), especially for newly planted shrubs and trees. Mulch should not touch tree trunks or canes of shrubs. For more information, see *Mulch Myths*, (HO-106).

#### Fertilize Lightly

Soil tests are the only means for determining nutrient deficiencies. Gardeners may supplement soil nutrients with light fertilizer applications according to test results. Applications should be broadcast across root systems, extending from trunks and beyond driplines. After deciduous plants enter dormancy in fall, apply fertilizer so that nutrients are available the following growing season. If lawn fertilizer is already applied around trees, additional fertilization should not be necessary. For more information, see *Principles of Home Landscape Fertilization* (ID-72). Fertilizer applications may further damage severely stressed trees, and a certified arborist should be consulted.

#### Proper Pruning

Remove dead, dying, and diseased branches. Other limbs should be selectively removed to improve plant form or health. Never top trees or remove more than one-fourth of live crowns. See *Warning: Topping is Hazardous to Your Tree’s Health!* (ID-55) on the dangers of topping trees.

Determine the best time to prune plants. Some deciduous woody plants can be pruned during the dormant season (winter and early spring prior to bud break), while others should be pruned after flowering. For more information on pruning, refer to the publications *Pruning Landscape Shrubs* (HO-59) and *Pruning Landscape Trees* (HO-45).

## Additional Resources

Plant Pathology Extension Publications:  
<http://www2.ca.uky.edu/agcollege/plantpathology/extension/pubs.html>  
Entomology Extension Publications (ENTFacts):<http://www2.ca.uky.edu/entomology/dept/entfacts.asp>  
Horticulture Extension Publications for Homeowners: <http://www.uky.edu/hort/home-horticulture>  
How Dry Seasons Affect Landscape Plants (ID-89): <http://www2.ca.uky.edu/agc/pubs/id/id89/id89.pdf>  
Iron Deficiency of Landscape Plants (ID-84):<http://www2.ca.uky.edu/agc/pubs/ID/ID84/ID84.pdf>  
Leaf Scorch and Winter Drying of Woody Plants (PPFS-W-OR-17):[http://www2.ca.uky.edu/agcollege/plantpathology/ext\\_files/PPFShtml/PPFS-OR-W-17.pdf](http://www2.ca.uky.edu/agcollege/plantpathology/ext_files/PPFShtml/PPFS-OR-W-17.pdf)  
Mulch Myths (HO-106): <http://www2.ca.uky.edu/agc/pubs/ho/ho106/ho106.pdf>  
Principles of Home Landscape Fertilization (ID-72):<http://www2.ca.uky.edu/agc/pubs/id/id72/id72.pdf>

Pruning Landscape Shrubs (HO-59):  
<http://www2.ca.uky.edu/agc/pubs/ho/ho59/ho59.pdf>  
Pruning Landscape Trees (HO-45):  
<http://www2.ca.uky.edu/agc/pubs/ho/ho45/ho45.pdf>  
Transplant Shock: Disease or Cultural Problem? (PPFS-OR-W-19): [http://www2.ca.uky.edu/agcollege/plantpathology/ext\\_files/PPFShtml/PPFS-OR-W-19.pdf](http://www2.ca.uky.edu/agcollege/plantpathology/ext_files/PPFShtml/PPFS-OR-W-19.pdf)  
Trees and Compacted Soils (HO-93):  
<http://www2.ca.uky.edu/agc/pubs/ho/ho93/ho93.pdf>  
UK Ag Weather Center Irrigation Manager: [http://weather.uky.edu/ky/agmodels.php#Irrigation\\_Manager](http://weather.uky.edu/ky/agmodels.php#Irrigation_Manager)  
Warning: Topping is Hazardous to Your Tree's Health! (ID-55): <http://www2.ca.uky.edu/agc/pubs/id/id55/id55.pdf>  
Weed Control for Kentucky Home Lawns (AGR-208): <http://www2.ca.uky.edu/agc/pubs/AGR/AGR208/AGR208.pdf>  
Wet Feet in the Landscape (PPFS-OR-W-04): [http://www2.ca.uky.edu/agcollege/plantpathology/ext\\_files/PPFShtml/PPFS-OR-W-4.pdf](http://www2.ca.uky.edu/agcollege/plantpathology/ext_files/PPFShtml/PPFS-OR-W-4.pdf)  
Wounds and Wood Decay of Trees (PPFS-OR-W-01): [http://www2.ca.uky.edu/agcollege/plantpathology/ext\\_files/PPFShtml/PPFS-OR-W-1.pdf](http://www2.ca.uky.edu/agcollege/plantpathology/ext_files/PPFShtml/PPFS-OR-W-1.pdf)

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