



## Shade and Flood Tolerance of Trees

*Wayne K. Clatterbuck, Associate Professor  
Forestry, Wildlife & Fisheries*

Most trees have very specific requirements for how much sunlight or shade that they are able to endure. Some trees do well in full sunlight, while other trees do not perform as well. Some trees are more adaptable than others to varying amounts of sunlight. Recognizing the light requirements of different species of trees will assist in proper tree selection in the landscape and will promote healthy trees.

As with light requirements, different trees have different tolerances to flooding. This factsheet discusses and lists the comparative tolerance of trees to shade or sunlight and to flooding.

### Shade Tolerance

Shade tolerance is a comparative term used to describe a tree species' ability to become established, grow and persist under shade or low light intensity, quality and duration. Tolerant species can grow comparatively well when little light is available. Intolerant species cannot grow well in low light levels, but grow very well at light levels approaching full sunlight. Other species are more flexible and are considered more intermediate between full sunlight and more shaded conditions. In forested areas, tolerant

trees reproduce and form understories beneath canopies of less tolerant trees or even beneath their own shade. Intolerant trees reproduce successfully only in the open or where large canopy gaps occur.

Knowledge of tolerance is necessary in establishing and managing trees in urban landscapes. Unfortunately, many shade-tolerant trees are planted in full sunlight conditions, increasing the stress and affecting their physiological processes. These trees usually do not adapt readily to increased light levels, usually decline and may eventually die. Dogwoods, sourwood and redbud are prime examples of shade-tolerant trees that are often planted in full sunlight. These trees are naturally found in the partial shade of the forest edge and interior. Shade-tolerant trees grow best in partial shade beneath larger trees or nearby structures or buildings that provide some shade during the day.

Sunlight is the key to successful flowering of trees. Enough sunlight must reach the tree for flowers and fruit to develop. Most flowering trees need at least half a day (four to six hours) of sunlight for good flowering. As the amount of sunlight decreases, so will the number of flowers. Thus, management of the amount of sunlight received by more



**Saucer magnolia is a shade-tolerant tree. The building in the background provides some shade during the day, but enough sun is received to provide bountiful blooms in the spring.**



**Pink and white dogwood in the partial shade of a mature American elm. Grouping of trees is one technique to provide some shade for shade-tolerant trees.**

shade-tolerant trees should be balanced to provide enough sunlight for flowering, but not so much that it affects the health of the tree.

No direct measure of shade tolerance is available, since tolerance is an expression of genetic and physiological response to an environment. Shade tolerance of trees with wide, north-to-south geographic ranges, such as sugar maple and ash in the eastern United States, differs with trees being more tolerant at the higher latitudes. Tolerance is not a constant for a species under all circumstances. Age affects tolerance, as trees usually become more intolerant with age. Most maples, oaks and eastern white pine are more shade-tolerant when young, but become more intolerant as they mature. Tolerant species are usually photosynthetically more efficient because they are able to utilize light at lower levels than shade-intolerant trees.

The morphology and physiology of leaves and trees that are tolerant and intolerant of shade are quite different. Table 1 provides some of these attributes of trees with different shade tolerances. Table 2 presents the accepted shade tolerance by species of many landscape trees found in Tennessee.

**Table 1 – Attributes of trees that change in relation to amount of sunlight.**

(Adapted from: Smith and others, 1997).

	Shade-Intolerant	Shade-Tolerant
<b>Leaf Morphology</b>		
Individual leaf area	Low	High
Leaf orientation	Erect	Horizontal
Leaf thickness	High	Low
Cuticle thickness	High	Low
Stomatal size	Small	Large
Stomatal density	High	Low
<b>Leaf Physiology</b>		
Light saturation rate	High	Low
Stomatal conductivity	High	Low
Water use efficiency	High	Low
Nitrogen use efficiency	High	Low
<b>Crown Morphology</b>		
Branch orientation	Erect	Horizontal
Branching pattern	Whorled	Branching
<b>Whole Plant Morphology</b>		
Allocation to leaves	Low	High
Allocation to roots	High	Low
Bole taper	Low	High
Live crown ratio	Low	High
Reproductive effort	High	Low
Seed size	Small	Large

## Flood Tolerance

Trees also have varying tolerances to flooding and inundation. A few days of flooding during the dormant season (November through March) has little effect on trees. However, flooding during the growing season, especially during and after leaf out, can be harmful to trees. The roots need oxygen to survive and grow. Flooding results in poor aeration, because the oxygen supply in flooded soil is severely limited. Oxygen deficiency is likely the most important environmental factor inhibiting growth and causing injury in flooded trees. Most trees will tolerate flowing water for a few days during the growing season. Flowing water retains dissolved oxygen (aerobic conditions) such that the oxygen to the roots is not depleted. However, oxygen is exhausted (anaerobic conditions) in water that is standing or puddled. Few trees can tolerate standing or puddled water during either the dormant or growing season.



**Water tupelo is one of the few trees that is flood-tolerant and can prosper in or near water.**

Once trees are stressed by floods (symptoms are leaf chlorosis, defoliation, reduced leaf size, sprouting and crown dieback), secondary organisms, particularly opportunistic fungi, insects and disease, invade the hosts and further weaken the tree. These symptoms may progress and eventually lead to tree death, especially with repeated, annual flooding. Generally, though, flooding does not occur each year and stress symptoms may subside, indicating the tree is recovering.

Some trees tolerate flooding better than others. Table 2 is a tolerance guide for planting and managing trees in

**Table 2 – Relative tolerance of trees to flooding and shade.**

(Adapted from Bratkovich and others, 1994; Burns and Honkala, 1990; Daniel and others, 1979; Gilman and Watson, 1993; Johnson, 1989; Whitlow and Harris 1979).

Species	Common Name	Tolerance <sup>1</sup>	Tolerance <sup>2</sup>
<i>Acer amur</i>	Amur maple	Intolerant	Intermediate
<i>Acer griseum</i>	Paperbark maple	Intolerant	Intermediate
<i>Acer negundo</i>	Boxelder	Tolerant	Tolerant
<i>Acer palmatum</i>	Japanese Maple	Intolerant	Tolerant
<i>Acer rubrum</i>	Red maple	Tolerant	Tolerant
<i>Acer saccharinum</i>	Silver maple	Tolerant	Tolerant
<i>Acer saccharum</i>	Sugar maple	Intermediate	Tolerant
<i>Aesculus</i> spp.	Buckeyes	Intermediate	Tolerant
<i>Amelanchier</i> spp.	Serviceberry	Intermediate	Intermediate
<i>Betula alleghaniensis</i>	Yellow birch	Intermediate	Intermediate
<i>Betula nigra</i>	River birch	Intermediate	Intolerant
<i>Betula papyrifera</i>	Paper birch	Intermediate	Intolerant
<i>Carpinus</i> spp.	Hornbeam	Intermediate	Tolerant
<i>Carya aquatica</i>	Water hickory	Tolerant	Intermediate
<i>Carya illinoensis</i>	Pecan	Tolerant	Intolerant
<i>Carya glabra</i>	Pignut hickory	Intolerant	Intermediate
<i>Carya laciniosa</i>	Shellbark hickory	Intermediate	Tolerant
<i>Carya ovata</i>	Shagbark hickory	Intolerant	Intermediate
<i>Carya tomentosa</i>	Mockernut hickory	Intolerant	Intolerant
<i>Celtis laevigata</i>	Sugarberry	Tolerant	Tolerant
<i>Celtis occidentalis</i>	Hackberry	Tolerant	Intermediate
<i>Cercis</i> spp.	Redbuds	Intolerant	Tolerant
<i>Chionanthus</i> spp.	Fringetree	Intermediate	Intermediate
<i>Cladrastis lutea</i>	Yellowwood	Intolerant	Intermediate
<i>Cotinus obovatus</i>	American smoketree	Intermediate	Intolerant
<i>Cornus florida</i>	Flowering dogwood	Intolerant	Tolerant
<i>Cornus kousa</i>	Kousa dogwood	Intolerant	Tolerant
<i>Crataegus</i> spp.	Hawthorns	Intolerant	Intermediate
<i>Diospyros virginiana</i>	Persimmon	Tolerant	Tolerant
<i>Fagus</i> spp.	Beech	Tolerant	Tolerant
<i>Fraxinus americana</i>	White ash	Intermediate	Intermediate
<i>Fraxinus pennsylvanica</i>	Green ash	Tolerant	Tolerant
<i>Ginkgo biloba</i>	Ginkgo	Intolerant	Intolerant
<i>Gleditsia triacanthos</i>	Honeylocust	Intermediate	Intolerant
<i>Gymnocladus dioicus</i>	Kentucky coffeetree	Intolerant	Intolerant
<i>Halesia carolina</i>	Silverbell	Intolerant	Tolerant
<i>Ilex opaca</i>	American holly	Intermediate	Tolerant
<i>Ilex x attenuata</i>	Foster holly	Intermediate	Tolerant
<i>Juglans cinerea</i>	Butternut, white walnut	Intolerant	Intolerant
<i>Juglans nigra</i>	Black walnut	Intermediate	Intolerant
<i>Juniperus virginiana</i>	Eastern redcedar	Intermediate	Intolerant
<i>Koelreuteria paniculata</i>	Golden raintree	Intolerant	Intolerant
<i>Lagerstroemia indica</i>	Crape-myrtle	Intolerant	Intolerant
<i>Liquidambar styraciflua</i>	Sweetgum	Tolerant	Intolerant
<i>Liriodendron tulipifera</i>	Yellow-poplar, tuliptree	Intolerant	Intolerant
<i>Magnolia acuminata</i>	Cucumbertree	Intolerant	Intermediate
<i>Magnolia grandifolia</i>	Southern magnolia	Intolerant	Tolerant
<i>Magnolia x soulangeana</i>	Saucer magnolia	Intolerant	Tolerant

**Table 2 (Continued)**

<b>Species</b>	<b>Common Name</b>	<b>Flood Tolerance<sup>1</sup></b>	<b>Shade Tolerance<sup>2</sup></b>
<i>Malus</i> spp.	Crabapples	Intolerant	Intermediate
<i>Nyssa aquatica</i>	Water tupelo	Tolerant	Intolerant
<i>Nyssa sylvatica</i>	Blackgum	Intermediate	Tolerant
<i>Ostrya virginiana</i>	Eastern hophornbeam	Intermediate	Tolerant
<i>Oxydendrum arboreum</i>	Sourwood	Intolerant	Tolerant
<i>Pinus echinata</i>	Shortleaf pine	Intolerant	Intolerant
<i>Pinus strobus</i>	Eastern white pine	Intolerant	Intermediate
<i>Pinus taeda</i>	Loblolly pine	Intermediate	Intolerant
<i>Plantanus occidentalis</i>	American sycamore	Tolerant	Intolerant
<i>Populus deltoides</i>	Eastern cottonwood	Tolerant	Intolerant
<i>Prunus</i> spp.	Cherries	Intolerant	Intolerant
<i>Pyrus calleryana</i>	Flowering pears	Intolerant	Intolerant
<i>Quercus alba</i>	White oak	Intolerant	Intermediate
<i>Quercus bicolor</i>	Swamp white oak	Intermediate	Intermediate
<i>Quercus coccinea</i>	Scarlet oak	Intolerant	Intolerant
<i>Quercus falcata</i>	Southern red oak	Intolerant	Intolerant
<i>Quercus lyrata</i>	Overcup oak	Tolerant	Intermediate
<i>Quercus macrocarpa</i>	Bur oak	Intermediate	Intermediate
<i>Quercus michauxii</i>	Swamp chestnut oak	Intermediate	Intolerant
<i>Quercus muehlenbergii</i>	Chinkapin oak	Intolerant	Intolerant
<i>Quercus nigra</i>	Water oak	Tolerant	Intermediate
<i>Quercus nuttalli</i>	Nuttall oak	Tolerant	Intolerant
<i>Quercus pagoda</i>	Cherrybark oak	Intermediate	Intolerant
<i>Quercus palustris</i>	Pin oak	Tolerant	Intolerant
<i>Quercus phellos</i>	Willow oak	Tolerant	Intolerant
<i>Quercus prinus</i>	Chestnut oak	Intolerant	Intermediate
<i>Quercus rubra</i>	Northern red oak	Intolerant	Intermediate
<i>Quercus shumardii</i>	Shumard oak	Intermediate	Intolerant
<i>Quercus stellata</i>	Post oak	Intolerant	Intolerant
<i>Quercus velutina</i>	Black oak	Intolerant	Intermediate
<i>Robinia psuedoacacia</i>	Black locust	Intolerant	Intolerant
<i>Salix</i> spp.	Willows	Tolerant	Intolerant
<i>Sassafras albidum</i>	Sassafras	Intolerant	Intolerant
<i>Taxodium distichum</i>	Baldcypress	Tolerant	Intermediate
<i>Thuja occidentalis</i>	Eastern arborvitae	Intolerant	Tolerant
<i>Tsuga canadensis</i>	Eastern hemlock	Intolerant	Tolerant
<i>Tilia americana</i>	American basswood	Intolerant	Tolerant
<i>Tilia cordata</i>	Littleleaf linden	Intermediate	Intermediate
<i>Ulmus alata</i>	Winged elm	Tolerant	Tolerant
<i>Ulmus americana</i>	American elm	Intermediate	Intermediate
<i>Ulmus parvifolia</i>	Lacebark elm	Intermediate	Intermediate
<i>Ulmus rubra</i>	Slippery elm	Intermediate	Tolerant
<i>Ulmus thomasii</i>	Rock elm	Intolerant	Intermediate

<sup>1</sup> Tolerant – Able to survive flooding or saturated soils for 30 to 120 consecutive days during the growing season; Intermediate – Able to survive flooding or saturated soils for up to 30 consecutive days during the growing season; Intolerant – Unable to survive more than a few days of flooding during the growing season.

<sup>2</sup> Comparative term to describe the ability of a tree species to survive and grow under low light levels: tolerant, intermediate, intolerant.



## Summary

Knowledge of the varying tolerances of different tree species to shade and flooding is critical in selecting *the right tree for the right place* for planting and for managing growth and development of trees in the landscape. Trees that are not well-suited to certain light and moisture conditions will perform poorly. Matching the tree's physiological requirements to its most conducive environment will increase the probability of success in managing your landscape with minimum maintenance costs.

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**Sweetgum is a shade-intolerant tree that is tolerant to flooding. It is preferred tree for fall coloration.**



**River birch can withstand some puddling of water for a short time.**



**A grouping of pin oaks that are shade-intolerant, but fairly tolerant to flooding.**

*Photos by Wayne Clatterbuck*

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