



# ENVIRONMENTAL INJURY: COLD TEMPERATURE INJURY OF LANDSCAPE WOODY ORNAMENTALS

Home Garden Series

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# Environmental Injury: Cold Temperature Injury of Landscape Woody Ornamentals

The seasonal cycles of active growth followed by the death-like winter appearance of deciduous trees and shrubs have been a source of wonder to humans since ancient times. Early philosophers thought that trees could survive the freezing winter months because they had a “natural heat” that prevented them from freezing during the long, cold winter. It was not until the early 1800s that scientists discredited this vital heat or “caloric theory” of plant freeze survival. Today, we think in terms of plant cold hardiness: the ability to adapt to and withstand freezing temperatures (Gusta and Wisniewski 2013).

## Plant Cold Hardiness

A plant’s cold hardiness, or its tolerance to freezing temperatures, is genetically determined. However, environmental conditions and cultural practices are factors that also influence a plant’s cold hardiness. The seasonal change in resistance to freezing temperatures occurs in response to environmental cues in plants that have the genetic capacity for cold hardiness.

The three components of cold hardiness are:

1. cold acclimation
2. ultimate or maximum mid-winter hardiness
3. deacclimation

Improper timing or insufficient development of any one of these components may limit plant survival.

## Acclimation, Maximum Mid-Winter Hardiness, and Deacclimation

Cold acclimation is a process involving physiological changes that occur within a plant, transforming it from a plant that is susceptible to freeze damage to one that is freeze tolerant or in a cold hardy condition. Cold acclimation occurs in response to changes in day length (i.e., photoperiod) and temperature.

In hardy trees and shrubs, cold acclimation is generally considered to be a two-stage process. The first stage is initiated by shorter day lengths later in the growing season, resulting in partial hardiness. The second stage is initiated by subfreezing temperatures and results in ultimate or maximum cold hardiness.

In general, actively growing plants cannot acclimate to cold temperatures (Figure 1). It is day lengths or photoperiods shorter than a certain critical length that provide the stimulus for cessation of above-ground plant growth. Shorter days initiate the biochemical and physiological processes associated with cold acclimation. Increasingly colder temperatures in autumn and winter induce additional physiological changes within the plant, allowing it to reach its maximum mid-winter hardiness.

In studies of northern hemisphere trees, the critical day length for growth cessation can vary from 12 to 22 hours depending on the species and latitude of origin (Olsen et al. 2004). Within a single species, the geographic origin of a plant plays an important role in the development of cold hardiness (Figure 2).



Figure 1. Late season growth prevents or delays cold acclimation in trees and shrubs. (Photo by Rita Hummel)



Figure 2. Redosier dogwood native to Alaska (left) and Utah (right) grown side-by-side in Puyallup, WA, respond differently to the shortening days of late summer. (Photo by Rita Hummel)

Redosier dogwood (*Cornus sericea*) collected from native stands in Alaska and native stands in Utah were grown side-by-side in a field near Minneapolis, Minnesota. On July 17, the Alaska plant had stopped growing and cold acclimated to survive freezing at 15°F, while the Utah plant was still growing (Hummel et al. 1982). Research indicates that this hardiness difference was caused by a differential response to day length. The Alaska plant is triggered to stop growing and cold acclimate when days are long while the Utah plant requires a shorter day length to stimulate cold acclimation.

Deacclimation describes a plant's loss of cold hardiness and is dependent primarily upon temperature. When the weather warms up in spring, plants deacclimate and their inactive buds start to grow.

Plants may also deacclimate in response to winter warm spells and may not reacclimate quickly enough when cold temperatures return. This results in cold temperature injury (Figure 3). The genetic make-up of the plant and the environmental conditions to which it is exposed interact to determine cold acclimation, ultimate mid-winter hardiness, and deacclimation.

## The Physiological Processes of Cold Hardening

During the cold hardening process, physiological changes occur in plant cells, including increased sugar concentration, protein modifications, and changes in the plasma membrane of plant cells. In hardy plants, when ice forms during freezing, it forms outside the cells in the spaces between the cells. Water from the cell moves through the surrounding plasma membrane to where ice crystals are forming between the cells. Cells shrink as they lose water and ice crystals grow outside the cells (Figure 4).



Figure 3. Spring frost damage to new growth on rhododendron that had deacclimated and was not cold hardy. (Photo by Ray Maleike, Ph.D., WSU Extension Horticulturist, Emeritus)



Figure 4. Leaf rolling in rhododendron is caused by cellular dehydration as water moves to spaces between cells and forms ice. (Photo by Ray Maleike)

Cold acclimation increases the tolerance of the plasma membrane to water movement and to freeze-induced dehydration due to the movement of water out of the cells. Cold temperature injury occurs from internal dehydration. Hardy plants can tolerate the dehydration, and when temperatures warm to above freezing, the ice between the cells thaws and water moves back into the cells.

## Symptoms of Cold Temperature Injury

The failure of formerly healthy buds, twigs, branches, or entire plants to leaf out in the spring can be indications of cold temperature injury. In springtime, some plants may at first appear unscathed, flowering and leafing out normally, and then suddenly start dying as the weather warms (Figure 5). Late development of leaves is also a symptom of cold temperature injury. The failure of spring blooming trees and shrubs to flower while still developing healthy leaves can also be a symptom of cold temperature injury.



Figure 5. The leaves (left) of this potted Doublefile viburnum (*Viburnum plicatum* f. *tomentosum*) started to grow and then collapsed in the spring as a result of freeze damage to roots the previous November. When the pot is removed (right), the dead roots can be seen. (Photos by Ray Maleike)

Flower buds are often damaged by freezes while vegetative buds and stem tissues remain unharmed (Figure 6). Root cold hardiness is usually not a problem for landscape plants established in the ground because the earth protects the roots from temperature extremes. As shown in Figure 5, plants in containers are more likely to have freeze-damaged roots.

Parts of a plant have differing hardiness levels, as shown in the chart in Figure 7. Generally, stems are hardier than vegetative buds, and vegetative buds are hardier than flower buds. Furthermore, flower buds are hardier than roots, with young roots being less cold hardy than older roots (Wiest and Steponkus 1976).



Figure 6. Flower buds and roots are less cold hardy plant tissues and more vulnerable to cold damage. On the left, some of the rhododendron flower buds were killed by cold temperatures, but the leaf buds are growing. On the right, the leaves and rhizomes (which are underground stems) of this potted pachysandra (*Pachysandra terminalis*) were not killed by the same cold temperatures that killed the roots. (Photos by Ray Maleike)



Figure 7. The hardiness of plant parts differ, with roots being the least hardy and stems being the most hardy.

## Causes of Cold Temperature Injury

Cold temperature injury occurs from internal dehydration when ice crystals form either within or between the cells of plant tissues. Damage can be caused if a plant is drought stressed going into winter or if the freezing temperatures are well below 32°F (0°C).

If the onset of cold weather is sudden, water may not have a chance to move out of plant cells. When this happens, depending on the severity and length of the freeze, ice can form within the cells and cause them to burst. For more information on cold-related environmental injuries, see the fact sheets on [Frost Cracks](#) and [Sunscald and Sunburn on Trees](#) in the WSU Extension Home Garden Series.

Cold temperature injury occurs when:

- Unseasonably low temperatures occur in the fall before plants are fully dormant and have not become fully acclimated.
- Temperatures drop below a plant's maximum mid-winter hardiness. Fully cold hardy plant tissues vary in their individual hardiness. Flower buds are less hardy than leaf buds, which are less hardy than woody tissues. Roots are one of the least hardy tissues, but soil provides protective insulation when planted in the ground. See Figures 5 and 6.
- Unseasonably low temperatures occur in late winter and early spring, often referred to as a "cold snap," when the plants have started to deacclimate in response to warming temperatures.
- Tree or shrub growth is stimulated by late summer to early fall fertilization and pruning. Plants with active growth late in the season experience delayed dormancy and acclimation, making them more susceptible to cold temperature injury.
- Trees or shrubs are weakened by drought stress and are more vulnerable to cold temperature injury going into fall and winter.

## Identification and Treatment of Cold Temperature Injury

When some injured plants are slow to leaf out, gardeners should not rush to prune off injured tissues. Scratch a small portion of the bark with your fingernail or the edge of a small knife blade to determine if there is any green tissue underneath the bark (Figures 8 and 9). If green tissue is visible, wait to see if growth resumes in the spring. Once it becomes obvious what tissue is still alive and what is not, you should remove the damaged branches immediately using proper pruning techniques.



Figure 8. To determine if tree or shrub branches have been killed or injured by cold temperatures, scratch a small portion of the bark with your fingernail or the edge of a small knife. If there is green tissue beneath the bark, wait to see if new growth begins in the spring. (Photo by Rita Hummel)



Figure 9. If the tissue beneath the bark is brown, it is likely that the branch is severely injured or dead and will not grow in the spring. (Photo by Rita Hummel)

## Prevention of Cold Temperature Injury

### Select Hardy Plants

Selecting cold hardy plants for the local climate is the best insurance against freeze damage. For help determining climate-appropriate cold hardy plants, visit a botanic garden or arboretum if there is one nearby. Well-kept old cemeteries can be a place to see and identify mature cold hardy trees and shrubs as well.

Many books and catalogs rate woody plants for winter hardiness using the USDA Plant Hardiness Zone System or a system of their own, such as the *New Sunset Western Garden Book*. The USDA's Plant Hardiness Zone Map rates plants according to the range of hardiness zones in which they survive.

An updated USDA Plant Hardiness Zone Map was released in 2012. This map divides the United States into 13 zones that differ from adjacent zones by 10 degrees; each 10-degree zone is further divided into 5-degree zones. The updated map is available online as an interactive GIS-based map at <http://planthardiness.ars.usda.gov/PHZMWeb/>.

A plant is more likely to be severely damaged or killed by winter cold if it is only marginally hardy in a particular zone. Marginally hardy plants are those that may experience winter damage; typically, they are rated as hardy in one zone but not in the next colder zone where they are marginally hardy. They may survive in the colder zone, especially if situated in a warmer microclimate within the landscape or given protection from cold winter temperatures.

When growing marginally hardy plants, it is especially important to avoid cultural practices in late summer that will encourage late season growth. These practices include fertilizing (Figure 10) and pruning (Figure 11). Also, stressed plants are more susceptible to cold temperature injury, so keep plants as healthy as possible during the growing season.

## Avoid Drought Stress

Roots do not cease growth in response to shortening day lengths and will continue to grow as long as soil temperatures are above freezing. Because moist soil stays warmer than dry soil, be sure that the soil is not dry going into cold weather. If fall and early winter weather is mild and dry, check the soil moisture and irrigate if needed. By watering and mulching you can provide some protection to the roots of plants growing in the ground.

## Apply Mulch

Snow and mulch provide insulation to roots. A 3- to 4-inch layer of coarse organic mulch such as bark, pine needles, or wood chips can help moderate soil temperatures, especially in regions where snow cover is negligible or unreliable. Keep the mulch close to, but not touching, the base of the plant. Mulch will also help conserve soil moisture. For information on using wood chip mulches, see WSU Extension Fact Sheet FS160E, [Using Arborist Wood Chips as Landscape Mulch](#).

## Protecting Trunks and Branches

Strategies for preventing damage to the trunk and branches from severe cold temperatures are limited, but some protection from frost cracks or damage to the southwest side of newly planted or thin-barked trees may be obtained from wrapping or shading the trunk. If tree trunks are wrapped for freeze protection, the wraps should be removed soon after the danger has passed.



Figure 10. The Japanese maple (*Acer palmatum*) on the left received a higher rate of nitrogen fertilizer, encouraging growth in late summer and making it susceptible to damage from a hard freeze in November. The maple on the right received a lower rate of nitrogen and was able to survive the same November freeze without damage. (Photo by Rita Hummel)



Figure 11. Pruning this marginally hardy plant late in the summer encouraged late season growth that is more susceptible to cold temperature damage. (Photo by Rita Hummel)

For more information, see the fact sheets on [Frost Cracks](#) and [Sunscald and Sunburn on Trees](#) in the WSU Extension Home Garden Series.

The need for freeze protection will depend on the plant selected and the nature of the freezing event, as well as how low the temperature drops and how long the cold lasts.

Other freeze protection strategies for use in the landscape include a consideration of the microclimate of the site. For example, cold air drainage down slopes, southern exposure, and warmer air temperatures near lakes or other water bodies will influence the potential for freeze damage to plants.

## Windbreaks

Windbreaks and shade provided by fences, buildings, hedges, trees, or natural landforms can also help protect susceptible plants like broad-leaved evergreens against foliar desiccation caused by drying winter winds and bright sunlight. For more information, see the fact sheets on [Frost Cracks](#) and [Sunscald and Sunburn on Trees](#) in the WSU Extension Home Garden Series.

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Use pesticides with care. Apply them only to plants, animals, or sites as listed on the label. When mixing and applying pesticides, follow all label precautions to protect yourself and others around you. It is a violation of the law to disregard label directions. If pesticides are spilled on skin or clothing, remove clothing and wash skin thoroughly. Store pesticides in their original containers and keep them out of the reach of children, pets, and livestock.

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