The Cold Truth About WINTER INJURY

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The extreme cold weather during the winter of 2002-2003 brought about some of the most widespread and severe winter injury to landscape trees and shrubs in Michigan in decades. Winter damage to newly installed plantings was especially severe and landscapers throughout Michigan were faced with significant warranty replacement issues. In some cases the winter damage may have been preventable while in many others winter injury would have been difficult to avoid due to the extreme weather.

The term "winter injury" actually encompasses a range of plant stresses and injuries. In order to adequately protect plants from winter injury, it is helpful to understand the different types of winter injury and how they occur. In this article I describe some of the most common types of winter injury that occur in Michigan and suggest possible solutions.

Cold Hardiness

Horticulturists have long recognized that minimum winter temperature is one of the primary factors limiting where a given species or cultivar may be grown. Cold hardiness refers to the relative ability of a plant to withstand cold temperature without freezing injury. For landscape plants this is most commonly expressed in terms of the hardiness zones developed by the USDA http://www.usna.usda.gov/Hardzone/ushzmap.html. The southern half of the Lower Peninsula is zone 5b (-10o to -15oF) with a few pockets of zone 6a and 6b (-5o to -10oF and 0o to -5oF, respectively) along the lakeshores and around Detroit. An important thing to remember about hardiness zones is that they reflect minimum temperatures in an average year based on long-term weather records, not the all-time extreme temperatures. For example, in Detroit the record low temperature is -20oF, which is 15o colder than the published hardiness zone, which is typical in Michigan (See table). So in extreme years, even plants that we presume to be hardy may suffer damage.

Another important thing to remember about cold hardiness is that level of hardiness varies from fall and winter to spring. In general, trees and shrubs achieve their maximum hardiness (able to withstand the coldest temperatures) in mid-winter (see figure 1). Most freezing injury is the result of cold temperatures during the hardening or de-hardening phase. Plants begin to harden in the fall in response to shortening daylength and gradually cooling temperatures. During this time plants break down starches and accumulate sugars and other solutes that act as 'anti-freeze' during the winter. In the spring, the processes are reversed and plants begin to de-harden and lose dormancy.

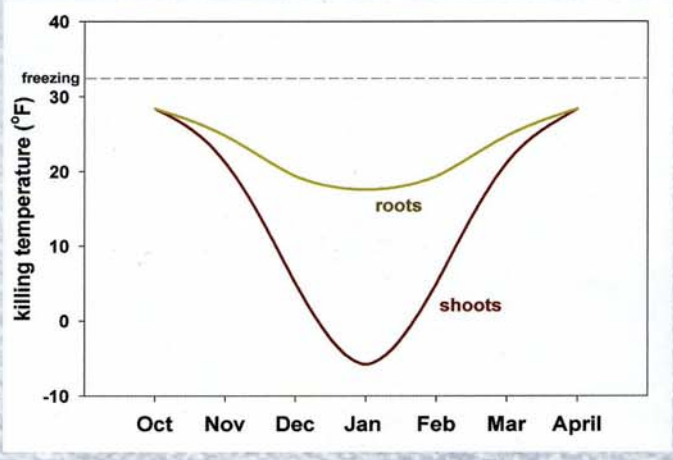

Figure 1. Generalized cold hardiness pattern of Douglas-fir shoots and roots during winter. Note that cold hardiness changes over the course of the winter and that roots are much less cold hardy than shoots. *Adapted from Ritchie 2002.*

All-Time Minimum Temperature for Selected Locations in Michigan

LOCATION	°F
Alpena	-36
Detroit	-20
Flint	-2
Grand Rapids	-20
Houghton Lake	-35
Lansing	-29
Marquette	-35
Muskegon	-15
Sault Ste.Marie	-36
Vanderbilt	-51

Figure 2. Late frost damage in balsam fir. The shoots had just broken bud then were frozen back

Freezing Injury

When plants experience temperatures colder than their hardiness level, freezing injury may occur. Freezing injury is largely due to formation of ice crystals within plant cells, which ruptures cell membranes and causes cell death. **Early frost injury** occurs early in the winter during the hardening phase. This is the type of injury we observe when an early 'Alberta Clipper' causes temperatures to nosedive in December. Late frost injury occurs late in the winter when plants have begun to deharden and, in some cases, have begun to break bud. **Late frost injury** is one of the most common forms of winter injury in Michigan and is frequently observed on early-breaking species and cultivars (see Figure 2).

Figure 3. Winter desiccation in Fraser fir.

Winter Desiccation

Winter desiccation is a common form of winter injury on conifers and broadleaved evergreens in Michigan. This injury is essentially a form of drought stress. It occurs when daytime temperatures rise above freezing especially on bright, windy days during the winter. Plants dehydrate as they lose water due to transpiration but cannot absorb water because the soil is frozen. Damage is typically most severe on the south and west side of plants and oftentimes an undamaged 'snowline' will be visible where snow cover protected foliage on lower limbs (see figure 3).

Frost Cracking

Many trees in Michigan suffer frost cracks during the winter. Frost cracks are associated with rapid fluctuations in stem temperature and, like winter desiccation, typically occur on the south or west side of the tree. On sunny days during the winter the stem is warmed and begins to thaw. When the stem is cooled at night the water in the tree re-freezes. The cycles of freezing and thawing result in expansion and contraction that may produce a frost crack, especially in thin barked species such as maples and sycamores (see figure 4)

Top, Figure 4. Frost cracking in sycamore. *Photo Courtesy of Paul Swartz, MSU Grounds Department.*

Above, Figure 5. Salt damage along I-94.

Salt Iinjury

Another common form of winter injury is exposure to de-icing salt. Each winter, road crews apply sodium chloride to keep snow and ice from building up on roadways. Many landscapers apply de-icing salt to keep walkways and parking lots clear as well. Sodium chloride can be taken up by the root system but the most acute damage is usually associated with exposure to salt spray and salt mist (see figure 5). The amount of salt exposure depends on many factors including vehicle traffic volume and speed. European researchers have found that significant amounts of road salt can be deposited up to a quarter of a mile away from the roadside (see figure 6).

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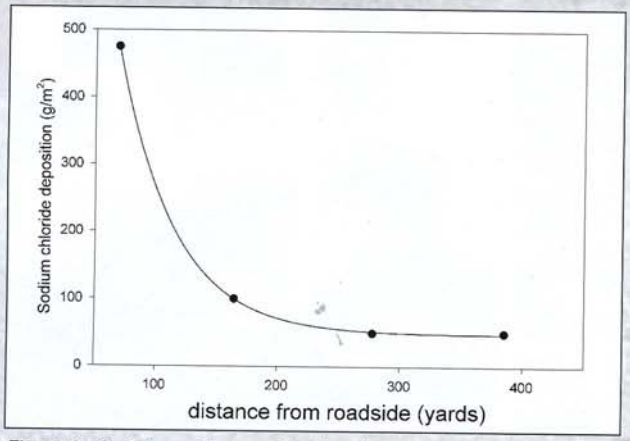

Figure 6. Salt deposition as affect by distance from the roadway. *Adapted from Pedersen et al. 2000. J. of Arboriculture 26:238-244.*

Solutions for Winter Injury: Selection and Protection

Select adapted trees and shrubs. One of the surest ways to minimize winter injury is to install plants that are reliably hardy in your zone. This is particularly important on sites that are exposed to wind and road salts. Books such as Michael Dirr's *Manual of Woody Landscape Plants* and Dirr's *Hardy Trees and Shrubs* list the hardiness zone of many common trees and shrubs. Information on hardy trees is also available on the web through links on my website http://www.hrt.msu.edu/faculty/list_cregg.htm

Figure 7. Barriers can reduce winter damage from salt spray and breakage from snow loads.

Protect trees and shrubs from exposure to salt and wind. This can be accomplished simply by constructing a barrier of burlap, landscape fabric or other screening materials (see figures 7 and 8). While the aesthetics of this type of protection may be debated, it is preferable to losing plants and replacing them under warranty. Anti-transpirants may provide some measure of protection for conifers and broadleaved evergreen. Remember, that film forming anti-transpirants such as Wilt-Pruf(wear off in 2-4 months so they may need to be re-applied for maximum protection.

Make sure plants are healthy going into winter. If plants are stressed going into winter they may not be able to fully harden and develop their maximum cold tolerance. This is especially critical for recently planted materials that are still coming out of transplant shock.

- Irrigate plantings in summer and early fall.
- Make sure plants have adequate nutrition. Potassium and calcium are especially critical for plants to achieve full cold hardiness.
- Avoid planting sensitive sites (e.g., areas exposed to high winds and salt) in the fall.
- Mulch plants. This will conserve soil moisture and also serve as an insulator to help protect sensitive feeder roots near the soil surface.

Figure 8. Landscapers and urban foresters in Denmark use these barriers to prevent road salt build-up in soils along roadways near Copenhagen. *Photo courtesy of Lars Bo Pedersen.*