# Winter Survival: A Tale of Plant Antifreeze and Exploding Trees

All living things must protect themselves against severe cold weather. With water, an essential compound in living tissue (it can make up to 60 to 90%), freezing temperatures can result in permanent damage. When the water within and between individual cells freezes, it forms ice crystals that readily puncture, shatter, and otherwise destroy those cells. Humans can usually circumvent this cellular horror by scurrying indoors or wearing protective gear. But what about plants, rooted in place and naked to the cold?

Here are some of the ways deciduous trees have evolved remarkable adaptations for winter survival:

**They go dormant.** Deciduous trees begin to enter dormancy in autumn as day length shortens and temperatures cool. They prepare above ground first. Trees withdraw the liquid — mostly water with dissolved sugars and salts — from their leaves, which subsequently wither and drop. Roots, in contrast, take longer to enter their winter rest. Because soil cools down much more slowly than air due to its greater mass, tree roots continue to grow for as long as the soil is suitably warm and moist, even when air temperatures are frigid. (Fall root growth makes autumn an ideal time to plant in many parts of the country.) Eventually, even the root growth slows, and the bare-branched trees rest, conserving their energy until they are ready to begin growth anew.

**They have bark.** Bark acts like a layer of insulation to help protect the internal living tissues from cold and fluctuations in temperatures that can interfere with dormancy. Light-colored and rough-textured bark reflect sunlight, which helps keep the surface cool and allows trees to remain dormant.

**They freeze-proof their cells.** Although leaves may have dropped, the remaining above-ground parts are still exposed to the cold. To reduce the chance of freeze damage, the trees concentrate sugars and salts in branches, twigs, buds, and other above-ground tissues. This effectively lowers the temperature at which the liquid freezes. Why?

Think road salt: When highway crews apply salt to icy roads, it interacts with the surface of the ice to create a liquid with a lower freezing point, effectively melting the ice. The saltier that liquid, the lower the freezing temperature. For practical purposes, when the temperature drops below 15°F, salt is no longer effective at melting ice. For reference, seawater freezes at about 28° F (-2° C), while water that is completely saturated with salt (so that no more can be dissolved in it) freezes at -6° F (-21° C).

In addition, some cold-climate plants manufacture "antifreeze proteins" that inhibit the formation of ice crystals. The liquid in the tissues might freeze, but it doesn't form those sharp, damaging shards.

**Their bare branches shed snow.** As anyone who has witnessed it can attest, an early snowfall in autumn — before deciduous trees have shed their leaves — can result in considerable damage as accumulated snow strains and breaks branches. However, in general, snow doesn't build up and damage deciduous trees that have already lost their leaves. (Ice storms, on the other hand, can wreak havoc!)

### The Costs and Benefits of Adaptations

Adaptations confer benefits, but these often come at a cost to the organism; that is, there's a trade-off. Most deciduous trees have broad, thin leaves that maximize the plants' photosynthetic capabilities, a decided benefit. Those leaves, however, would be very vulnerable to freeze damage, so the plant discards them at the end of the growing season and incurs the cost (high energy expenditure) of producing new foliage each spring.

Interestingly, forests in far northern and high-elevation habitats are predominantly evergreen. At first glance, this doesn't seem to make sense. Wouldn't the adaptations of deciduous trees — especially leaf drops — allow them to thrive in cold regions? And what about the snow load on heavily needled evergreen branches?

Scientists hypothesize that evergreens dominate cold-climate habitats because the growing season is short and the ground is frozen for much of the year (so roots are unable to take up water), both of which reduce the window during which the trees can perform photosynthesis and produce the food they need to survive. They simply can't afford to spend a hefty portion of that time each spring growing new foliage!

As you'd expect, there are costs to evergreen trees' advantage of not having to regrow their leaves, and one of those costs is a reduction in the efficiency of photosynthesis. The foliage on many evergreens is narrow and needle-like (resulting in a reduced surface area to capture the sun's rays), and it often has a protective waxy coating, both of which inhibit photosynthesis capability.

## Exploding Trees

These adaptations do not constitute a fail-safe system. An important springtime ritual is surveying trees and shrubs for winter damage – broken branches, cracked bark, twig die-back, and other signs of winter stress. In the wild, most trees recover from winter damage, though any open wounds invite insects and fungi to enter. In cultivated landscapes, damage to large limbs may disfigure trees and require the skills of an arborist to check for safety.

Have you ever heard odd bangs or popping sounds in the forest (or even in your neighborhood) and wondered what they were? It's possible you heard a tree exploding! When temperatures are unseasonably frigid or drop to extremes, a tree's sap can freeze and expand. If the rigid bark can't accommodate the increased mass…boom! The bark cracks open, and the wood might even shatter with an explosive fury.

This fascinating phenomenon is nothing new. The name in the Lakota lunar calendar for the month we call February is Čhaŋnápȟopa Wí, which translates to "The moon of popping trees." Listen closely on cold winter nights, and you just might hear a pop!

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