Soil in Winter: What's Happening Underfoot?

In all but the warmest climates, late fall spells the end of the growing season. As plants die back with the first hard frost and we hunker down for cold winter temperatures, what's happening in the soil? Although our gardening activities slow down and eventually cease as frigid temperatures arrive, life underfoot continues to thrive for weeks — or even months — as long as the soil remains unfrozen.

During the warm, sunny days of spring, summer, and early fall, soil slowly absorbs and stores the sun's heat energy. Then, when air temperatures drop below 32˚F (0˚C) for short periods of time, the surface layer of soil begins to freeze. However, it takes prolonged cold temperatures to freeze the deeper layers of soil.

Why is soil slower to freeze than air? Because the mass of soil is much larger compared to that of air, it takes longer to heat and cool it. In other words, short-term swings in air temperature won't have much effect on soil temperature. Soil stays warmer for longer in fall, meaning that roots can continue to grow into fall and early winter. The longer freezing temperatures persist aboveground, the deeper the soil freezes. In regions with relatively mild winters, soil may freeze to a depth of just a few inches (or may not freeze at all), while in the coldest regions, soil may freeze to a depth of 4' or more! The average depth to which soil freezes is called the *frost line*. Soils that remain frozen for two or more years are considered *permafrost*.

In addition to air temperatures, other environmental factors also affect how deeply soils freeze.

- Snow cover acts as an insulator, holding in the soil's warmth. In areas with reliable snow cover all winter, soils may remain significantly warmer than in areas with sparse or sporadic snow cover.
- A layer of organic matter, such as fallen leaves in the woods or a blanket of straw in the vegetable garden, will insulate soil and keep it warmer longer into winter.
- Buildings and areas of pavement absorb and release heat and may keep soil warmer than areas further away from these features.
- Compacted soils freeze more deeply than loose soils that contain lots of insulating air pockets.

How Organisms Survive the Cold

Plants. Plants have adapted strategies to tolerate the conditions in their native soils. Perennial plants, trees, and shrubs that grow where the ground freezes often have deep root systems that extend below the frost line. Some plants' roots release water from their cells into the surrounding soil; this concentrates sugars and salts within the roots' cells, lowering the temperature at which they'll freeze. It also minimizes damage caused by ice crystal formation when root cells do freeze. Learn more about winter adaptations of plants in Winter Survival < https://kidsgardening.org/resources/digging-deeper-winter-survival/>.

Animals. Many reptiles and amphibians, including species of snakes, turtles, and salamanders, burrow deep into the soil (or crawl into abandoned animal burrows) to survive the winter. Some earthworms burrow down beneath the frost line for the winter; other types produce eggs in cases called cocoons and survive winter in that state, ready to hatch in spring. Various insect species go into a hibernation-like state called diapause and remain dormant over the winter. Many mammals seek out or create shelters, such as dens, and then enter hibernation (or hibernation-like states) during which their metabolic, heart, and respiratory rates slow and their body temperatures drop. These changes reduce energy consumption and allow them to survive the winter without eating or drinking.

Soil-dwelling microbes. Many microscopic organisms, such as fungi and bacteria, remain active as long as the soil isn't frozen, continuing their work of breaking down organic matter and cycling nutrients. In some cases, their activity actually increases after a hard frost kills plants and the dead roots begin to decompose.

Considerations for Gardeners

Healthy soil is the foundation of healthy gardens. Here are some tips for caring for soil in winter and throughout the whole year so it's primed to support your garden plants during the growing season.

- Deep, loose soils that are high in organic matter encourage deep root systems that can withstand a wider range of soil conditions than shallower roots. Adding compost and growing cover crops are two ways to loosen soil, increase organic matter, and support soil life. Avoid over-tilling, because this damages soil structure and may lead to compacted soil.
- After the harvest, add a layer of organic mulch over vegetable garden beds, such as compost, shredded leaves, or straw. This will keep the soil warmer for longer and provide some added food for soil-dwelling organisms. It will also protect the soil from pelting rain that can cause compaction and erosion.
- In all but the coldest regions, a deep layer of loose organic mulch such as straw over a bed of carrots, beets, or other root vegetables will insulate soil from cold air temperatures, allowing gardeners to harvest the roots into late fall or even throughout the winter.
- It's generally advisable to wait until after the ground freezes to mulch perennials and woody plants to ensure they've fully entered dormancy. Mulch them too early and the warm soil may "trick" plants into thinking there's still time to produce new foliage that would then be killed during the next cold snap, wasting the plants' precious energy reserves.
- In areas where air temperatures regularly fluctuate above and below freezing in winter, it's a good idea to mulch shallow-rooted perennial plants after the ground freezes. Mulching insulates the soil from repeated freeze-thaw cycles that cause soil to expand and contract, which can lift or "heave" the plants out of the soil, damaging roots. This is also a good practice for newly planted perennials, shrubs, and trees that haven't had time to establish deep root systems.
- Thin mulch (or remove it entirely for a short time) from vegetable gardens in early spring to allow the sun's warmth to heat up and dry out the soil.