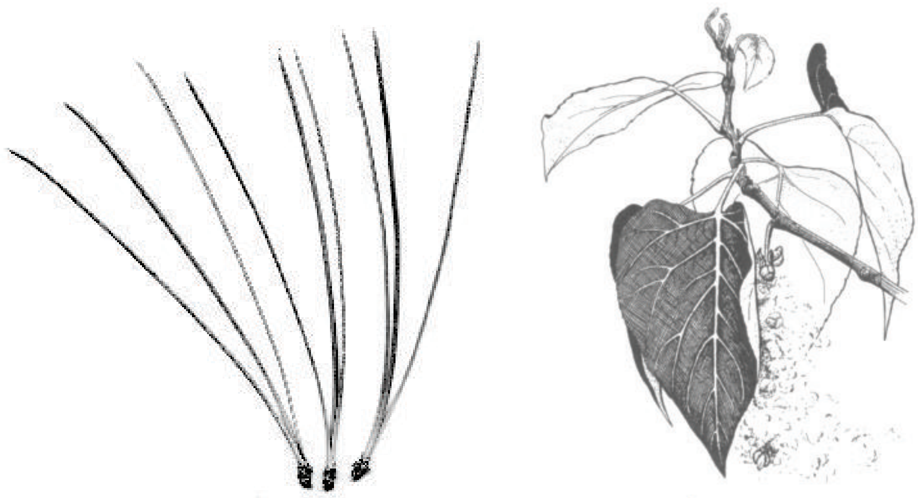
Comparing Conifers and Broadleaf Trees

Why two completely different strategies for how to be a tree work equally well

by Sandra Strieby



Different designs for photosynthesis: pine needles and cottonwood leaves

From the window of my home office, I can look through a grove of loosely-spaced Ponderosa Pines (*Pinus ponderosa*) and into a dense floodplain gallery of Black Cottonwoods (*Populus trichocarpa*) interspersed with a few Mountain Alders (*Alnus incana*). As I write this article, in late February, the pines are beautiful, with their cinnamon-orange bark and green needles highlighted by snow. The beauty of the deciduous trees is starker—at this season, unlike the pines, the cottonwoods and alders have no leaves.

The Black Cottonwoods and Ponderosa Pines, the Methow Valley's iconic tree species, represent two different divisions of plants and two very different evolutionary strategies. Both species rely on their leaves to convert water, carbon dioxide, and nutrients into energy that they can use to grow and reproduce. But they go about it in very different ways. Most (not all) conifers keep their leaves year round, while many broadleaved trees (including all of those that grow in the Methow) shed their leaves in the fall and grow new ones in the spring—an approach to life that seems wasteful, if not downright profligate, on its face. But nature is nothing if not efficient, so…there must be a reason.

How, exactly, do conifers and broadleaved trees approach the task of surviving and reproducing? What does each have to gain from its way of doing things? How does each one use the resources at its disposal to thrive?

In this article, I'll be writing about evergreen conifers—those that keep their leaves during the winter—and deciduous broadleaves—those that lose their leaves in the fall. That applies to all of the trees that are native to the Methow Watershed, with two exceptions—the Alpine and Western larches (*Larix lyallii* and *L. occidentalis*)—deciduous conifers that have adapted to extreme environments by adopting characteristics of both types of tree.

Deciduous trees are those that drop their leaves at the end of the growing season and produce new leaves in the spring. They are generally angiosperms, or flowering plants. Flowering *trees* are also known as broadleaved trees. Flowering plants are much more recent arrivals than the conifers, or gymnosperms. The table below shows some of the distinctions between flowering plants and conifers.

Although they are relative newcomers, flowering plants have enjoyed considerable success. Broadleaved trees compete well with conifers in many environments. One advantage that has enabled them to compete for resources is annual leaf loss.

Annual leaf loss may seem like a surprising competitive strategy. Keeping leaves for several years saves a tree the cost of creating them anew every spring. Conifer needles last for several years, with spruce needles living up to a decade and those of Bristlecone pines lasting 20, 30, or even as long as 40 years. Holding onto needles during the winter also allows the tree to photosynthesize year round…as long as temperatures are mild enough and days long enough. In a few very harsh envi-

Sandra Strieby is a land use planner, landscape designer, and naturalist living in Twisp.

Scientific Name	Common Name	Age	Etymology	Distinguishing characteristic
Angiosperms	Flowering plants	140 million years old	Angeion = vessel sperm = seed	Angiosperms bear seeds in protective a *vessel* called a *fruit* –this goes by many names depending in its shape: berry, pome, drupe, pod, etc.
Gymnosperms	Conifers	300 million years old	Gymno = bare Conus = cone	Gymnosperms do not produce a protective covering—their seeds are *bare*, although they may be well protected by a sharp-toothed *cone*.

Characteristics of flowering plants--which includes all broadleaf trees--and conifers

ronments, winter needles may not offer that advantage. Deciduous conifers like larches have evolved to occupy those demanding niches.

However, leaves must be tough to survive the winter. They are subject to desiccation (drying out) when the air is cold and dry, abrasion from snow and ice, and browsing by animals that have fewer food sources in winter that during the growing season. One way conifers protect their leaves is with a waxy coating, the cuticle, which helps prevent water loss and makes the leaves more durable and less palatable than their undefended counterparts. Growing a cuticle comes at a price, though. It requires an investment of carbon, which the tree must recruit via photosynthesis. Individual trees, and each species as a whole, must find just the right balance between costs (like growing a cuticle) and benefits (like durable leaves) that foster survival.

Whereas conifers invest in growing long-lived leaves, deciduous trees put their resources into creating more leaf area. Since they photosynthesize for only a short period, they must catch as much sun as they can during the months when they are in leaf.

The leaves of many conifers are known as needles, for their slender form as well as their pointy tips. Other conifers grow scale-like leaves—the Western Red-Cedar (*Thuja plicata*) is a local example. In either case, conifer leaves are compact. The compact form minimizes surface area and so reduces water loss. It also enables the leaf to bury its vascular tissue—through which water moves—in protective photosynthetic tissue. The cells that use sunlight are close to the surface, while the water-bearing cells are deep in the needle, keeping the precious liquid safe from evaporation.

Deciduous trees take a different approach. Rather than try to conserve water, they grow where there is more of it—for instance, along watercourses, in the shade of conifers, or in places with high summer precipitation. Then they spread their leaves wide to catch as much sun as possible. In the course of a season, many of those leaves will be torn by the wind, eaten by insects, pecked by birds, and colonized by fungi and bacteria. The overall leaf area is so much greater, though, that the short-lived leaves are still a good investment. Their photosynthetic capacity—that is, their ability to capture carbon and convert it to nutrients—is greater than that of the longer-lived coniferous leaves.

So, what other mechanisms do conifers use to maintain their competitive edge? Canopy shape and needle arrangement both work in their favor. The classic conical shape intercepts sunlight more efficiently than a rounded canopy. A very broad canopy would also catch a lot of sun, but, in a climate like ours, it would be too susceptible to damage by ice and snow to be efficient. In the Methow, even deciduous trees tend to be fairly upright in form so that their branches are less likely to catch snow and less likely to break when snow does accumulate. Losing leaves helps protect deciduous trees' branches, too. Whereas conifers are shaped to shed snow, the upright branches of broadleaved trees would be further compromised if the leaves were present in winter.

Conifer needles tend to be clustered on branches, helping light to penetrate the canopy. And, because the needles are small and tend to be relatively widely spaced on the tree, light can also spread more easily once it is within the canopy. Looking at those Ponderosa Pines outside my window, I can see that almost all the needles are being touched by the sun. In contrast, shade keeps many deciduous leaves from achieving their photosynthetic potential.

As noted above, deciduous leaves have greater photosynthetic ability than do coniferous ones. That is partly because of their greater surface area, and partly because they invest more nitrogen in leaf building to begin with. High-nitrogen leaves photosynthesize more efficiently. They are also more costly to maintain, being better stocked with proteins and other energy-demanding components. So, it makes sense for the tree to shed them at the start of the cold season and produce new ones in the spring…if there is an adequate supply of nutrients with which to create those new leaves, that is.

Where nutrients are in short supply, the evergreen habit may be more efficient. That is at least part of the reason conifers tend to predominate at higher elevations in the Methow. Long-lasting leaves represent a smaller annual investment of nitrogen, which can be a limiting factor in cold or dry places. The cuticle that coats conifer leaves also helps keep nutrients in the leaves; they are less likely to be leached by precipitation than are the nutrients in deciduous leaves, at least in the short run. In the course of a needle's life, it may lose as many nutrients as a deciduous leaf would in its few months on the tree, but in a single year, it will lose much less nitrogen.

Continued on page 16....

Methow Naturalist
PO Box 175
Winthrop, WA 98862
www.methownaturalist.com

PRSRT STD
U.S. POSTAGE PAID
TWISP, WA
PERMIT NO. 14

Subscriptions: $10 or more/year: Methow Naturalist, PO Box 175, Winthrop, WA 98862 Contact: dana@methownet.com

Conifers & Broadleaves, continued from page 5...

Finally, conifers and broadleaved trees use different mechanisms to conduct water. In conifers, water moves in structures called tracheids. In broadleaved trees, water moves in more efficient structures called vessels as well as in tracheids, further supporting faster growth and larger leaves.

All of those adaptations add up to improved ability to survive and reproduce in a particular environment. Here in the Methow, both conifers and deciduous trees have found niches. Deciduous trees generally predominate close to reliable water sources—where resources are plentiful, their adaptations have given them the edge. Conifers may also grow in riparian areas, but they are also able to survive in upland environments. It is there that their ability to weather harsher conditions becomes a real advantage.

Other environments are dominated by either coniferous or deciduous trees. The maritime northwest is an example of an area dominated by conifers. It appears that the northwest's dry summers give conifers an advantage. Photosynthesis may stop or slow way down as trees close the stomata in their leaves to reduce evapotranspiration—a real hindrance to trees that only bear leaves for a few months a year. In the winter, temperatures are generally mild enough that conifers can keep photosynthesizing, and, of course, there is plenty of rain to fuel growth.

Conifers are the tallest (redwoods, above), oldest (bristlecone pines) an most massive (sequoia) organisms on the planet.

At the opposite end of the spectrum are tropical rainforests, which tend to be dominated by broadleaved evergreen trees. When conditions are favorable, broad leaves are more efficient than the needles and scales of conifers. Conditions in tropical rainforests are favorable in two respects: neither temperature nor moisture limits growth. In places where the growing season is not interrupted by cold winters, even angiosperms can photosynthesize all year round—and they don't need tough needles and scales to do it. Neither do they need to conserve water, so leaf forms that limit surface area and evapotranspiration are not needed.

On the other hand, nutrients are likely to be limiting in tropical rainforests—the high rainfall leaches them from the soil—so an evergreen habit confers another advantage, allowing leaves to make use of nutrients for a longer period as well as take advantage of the sunlight year-round. The vessels that angiosperms use to transport water may even help their seedlings get off to a faster start than those of conifers.

The very harsh winter environments found at high altitudes and high latitudes are a third extreme, and one that has led to a specialized adaptation: deciduous conifers. The larches, mentioned early in this article, are the best known example; a few other genera occur world-wide. Larches rely on needles rather than broad leaves *and* they grow new needles every year (although the needles of juvenile trees may survive the first winter—perhaps protected by the forest canopy above). How do they do it? First, they grow in areas where there is little competition—other trees are not adapted to the harsh environments in which larches have established themselves. And second, they rely on efficient form and efficient use of nutrients to capture light and grow leaves and structural components.