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Links: http://tidcf.nrcan.gc.ca/en/diseases
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Scientists at Pacific Forestry Centre

Research Drought Tolerance

Water is one of the most common limiting factors in production systems. Drought tolerance allows plants to survive and grow relative to another individual or group. Since trees are the tallest species on the planet, moving water from one area to another within the tree presents a particular challenge. Tolerance varies within a tree species, for example, pines generally are more tolerant than hemlocks, but there is also variation within a species population. Drought tolerance is becoming increasingly important for maintaining productivity of forests, especially in areas where limited moisture has not previously been a problem.

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Drought tolerance variation and relation to other tolerance traits

Trees that live on the edge of the species range in drier areas usually have increased drought tolerance through natural selection. How much tolerance exists within a species is an important question for tree breeders. Drought tolerance traits can include thicker wax coverings on leaves to prevent evaporation, more efficient use of water per unit of carbohydrate produced or better extraction of water by root systems. These traits can combine in various ways in a population to produce a range of drought tolerant traits.

Tree breeders look for these traits, except that desirable traits can also have trade-offs with each other. For example, a tree may be highly drought tolerant but it may have reduced disease resistance to a pathogen as a result.

A dying hemlock

Drought susceptible species on Vancouver Island include Western redcedar and hemlock.

Photo Credit: www.naturallywood.com

Determining just which traits are positive, negative or have no correlation is no easy problem to solve since trees have very long lifespans difficult to simulate in controlled experiments. More importantly, two stresses occurring simultaneously may have greater impact than when their impacts are considered separately.

Stressing Douglas-fir

At the Pacific Forest Centre, the Canadian Wood Fibre Centre (CWFC) of Natural Resources Canada has partnered with the B.C. Ministry of Forests, Lands, Natural Resource Operations and Rural Development to screen Douglas-fir seedlings for four stresses: two root pathogens, the fungus carried by the Douglas-fir beetle and drought. There is considerable variation in the tree response to most of these stresses, indicating that different trees use different methods to cope with stress. Furthermore, trees that cope well in one stress do not necessarily cope well for a second stress, but a few do moderately well to all of them. The good news is resistance to Armillaria root disease had some positive correlation with drought tolerance, likely because both stresses affect water balance within the tree.

Pacific Forestry Centre experiment screens Douglas-fir seedlings for four stresses: two root pathogens, the fungus carried by the Douglas-fir beetle and drought.

To find trees with desirable traits, seedlings are subjected to drought and other stresses to find individuals that do well. Genes within these trees can be identified and used as markers to screen a larger population of trees that also do well. Once identified, these trees are planted into longer-term trials in the natural environment to confirm their adaptability. Seed from these trees can then be recommended for use in areas known to have particular stresses now or in the future. Since trees are long-lived in one place, they experience multiple stresses over their life that they cannot easily avoid. Knowing which trees have beneficial traits to multiple stresses will help make decisions in the future.

Drought tolerance and western redcedar species mixtures

The CWFC is also investigating how gene expression for drought tolerance is affected by tree species mixtures. Drought is becoming a problem for western redcedar at the southern edge of its range in BC. At least for some years, summers are becoming hotter and drier, and it only takes one of these years to kill trees. Further, mixing tree species may affect compatibility to drought. Tree mixtures that pair drought tolerant species with intolerant species appears to be a problem for the intolerant species. In fact, western redcedar and Douglas-fir may be such a pair. Often found together, the Douglas-fir is a fast grower and drought tolerant, extracting the soil moisture in dry years while exacerbating the problem for the slower growing less tolerant cedar. Pacific Forestry Centre is also investigating if this species pairing affects the level of extractives within the tree that give cedar its natural decay durability.

Great Heights

Trees grow by extracting water and nutrients from the soil and processing them into carbohydrates for growth using sunlight as an energy source (photosynthesis). The tree must move the water upwards against gravity. It does this through hollow cells in the sapwood. These fibres align end to end and form a vertical pipeline between the roots and leaves. Water evaporates at the leaf surface, which pulls the water upwards through the pipe. The negative pressure created by evaporation can become so great that air can leak into the pipeline and prevent the water flow. The tree is in serious trouble if this occurs. Fortunately, the cells produced at the end of the season called latewood have very thick cell walls and very small internal diameters, which make them resistant to this kind of problem. The latewood can become the only functional pipeline in severe drought representing only a smaller fraction of the tree vascular system that keeps the tree alive.