What's in your planting bag?

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Genetic resistance to white pine blister rust (WPBR) will play a critical role in the future trajectory of whitebark pine and the other high elevation white pines. However, as we found during the field trips at the WPEF Science Conference in September, the terminology associated with genetic disease resistance can get confusing, e.g. not all seed trees are plus trees and not all plus trees have genetic resistance.

Until seed orchards produce sufficient seed for planting projects, seed will be collected from wild forest-grown trees. So let's start with some terminology related to forest seed trees as they relate to WPBR resistance.

Planted whitebark pine seedling in Idaho.

Planted limber pine seedling in Oregon.

Seed tree = an individual tree from which seed is collected (or intend to be collected). The tree is often not selected for sampling on the basis of any field characteristics related to presumed WPBR resistance – this might be because the stand has not yet been invaded by WPBR, infection is very low in the stand, or the collector did not scout based on rust disease symptoms. Some call this a "random seed tree" though the trees are not selected at random – they are selected for general health (factors other than WPBR), cone production, accessibility, position in the stand, etc. If the individual-tree seed collection is to be tested for rust resistance, the seed tree is usually tagged and georeferenced.

Putatively resistant seed tree = a seed tree that is selected for seed collection because it has little to no observed WPBR symptoms in a stand where other trees are heavily infected or dead from rust. Since it is healthier than most the trees in the stand, it is presumed to possibly have genetic resistance to WPBR. Because rust incidence varies across the landscape, so will the likelihood of a putatively resistant seed tree actually having genetic resistance. Until the progeny of the putatively resistant seed tree are screened for rust resistance, it is not known if it has heritable WPBR resistance traits; it may have escaped exposure or infection by the rust in the field for other unknown reasons.

Plus tree = a putatively resistant seed tree that is tagged and georeferenced and its seed is collected expressly for rust resistance screening.

Elite tree = a seed tree or plus tree that is confirmed via rust resistance testing to carry heritable WPBR resistance traits. Each program sets its own criteria for what level of disease resistance is required to designate a seed tree as "elite".

One source of confusion can result from a program's attempts to identify plus trees across broad geographic areas or seed zones. In some areas the disease is absent or at low incidence, and therefore such a tree is actually a seed tree, and not a putatively resistant tree with suspected WPBR resistance traits (therefore technically not a plus tree either). Consequently, the likelihood of the sampled trees having genetic resistance is not equal across the landscape. So if the seed trees from the relatively healthy

locations are shown to lack resistance in testing that does not necessarily mean that the population from which they were sampled has fewer resistant trees than any other. It just means our sampling to detect resistance in a healthy stand is less efficient than in a stand where many of the susceptible trees are already infected or dead, and more seed trees will need to be sampled and tested to identify elite trees with genetic resistance to WPBR.

How seed (from the appropriate seed zone) are collected and combined to generate a seed lot for seedling production will affect the certainty of rust resistance characteristics being present and therefore its potential field performance upon planting.

Bulked seedling lot = seedlings grown from seed collected from multiple seed trees with no field selection regarding WPBR susceptibility or suspected resistance within a population.

Putatively resistant bulked seedling lot = seedling grown from seed from putatively resistant seed trees that have not undergone progeny testing for genetic resistance. The level of resistance may be greater than a bulked seedling lot but how much better cannot be estimated without testing.

Resistant bulked seedling lot = seedlings grown from seed from multiple elite seed trees. The level of WPBR resistance should be higher than a bulked or putatively resistant bulked seedling lot, but some seedlings from this lot will still be expected to get infected and die.

Improved resistant seedling lot = seedlings grown for seed from a seed orchard.

These terms reflect expected relative resistance rankings of seedling lots but do not alone inform you of how many of the seedlings in a lot have resistance. Regardless of the seed lot type (bulk, putatively resistant bulk, resistant bulk, or improved), there will always be some proportion of the seedlings that are fully susceptible to WPBR.

An estimate of what proportion of the seedlings will die from WPBR will differ, and best estimates can only be achieved by thorough testing a subset of seedlings of the seed lot for resistance to WPBR. (This proportion that die may also vary with rust hazard at the planting site – but that is another discussion).

Knowing the proportion of seedlings expected to have resistance to WPBR in your seed lot, and therefore the proportion of fully susceptible seedlings in your lot, is helpful for determining planting densities. For example, if the target outcome of a planting is 100 trees per acre, and you expect 20% of the seedlings to die before establishment and the seed lot has shown 50% survival in WPBR resistance testing, a planting density of 240 seedlings per acre would be appropriate.

So what is in your planting bag? What the lot is called is less important than knowing the estimated proportion of seedlings that have resistance to WPBR. Only testing the lot can provide that information, reduce uncertainty and help justify and align expectations of the long-term success of the planting.

Note: I'd like to thank Cyndi Smith for the invitation to contribute this discussion and Angelia Kegley for helpful comments on earlier draft. Further information on some of these points can be found in Schoettle AW, Jacobi WR, Waring KM, Burns KS. 2018. Regeneration for Resilience framework to support regeneration decisions for species with populations at risk of extirpation by white pine blister rust. New Forests – in press. https://doi.org/10.1007/s11056-018-9679-8

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