Douglas-fir Breeding: Past Successes and Future Challenges

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Breeding programs in Douglas-fir are among the most extensive in the world, with more than 4 million progeny from nearly 34,000 selected parents growing on almost 1,000 test sites in the Pacific Northwest (PNW). The PNW is an environmentally diverse, mountainous region with large tracts of public and private forestlands, and a public with strong environmental values. Not surprisingly, these factors influence forest management and tree breeding. Compared to the southern pines, Douglas-fir breeding programs typically maintain greater genetic diversity, make selections at older ages, use simpler mating designs, rely more heavily on open-pollinated seed orchards, and do not anticipate the widespread use of clonal forestry or genetically engineered trees. The primary breeding goals of increasing crop value and maintaining adaptability are generally met in different ways. Eight breeding zones in OR and WA are used to maintain adaptability to frosts and droughts, whereas breeding within these well-adapted populations is used to improve growth and (secondarily) stem quality and wood density. Most breeding occurs via a decentralized system of independent metacooperatives that are coordinated by an umbrella organization called the Northwest Tree Improvement Cooperative. A separate organization, the Pacific Northwest Tree Improvement Research Cooperative, focuses on tree breeding research. Other programs are managed by the British Columbia Ministry of Forests, Inland Empire Tree Improvement Cooperative, and a few private companies.

Historically, research focused on seed orchards (e.g., graft incompatibility, pollen contamination) and quantifying patterns of adaptive genetic variation. Other topics have attracted more recent attention, including: To what extent should wood properties be included in breeding programs? How can genetics be incorporated into growth models to predict gains over a rotation? Can miniaturized seed orchards be used to increase genetic gains and lower seed orchard costs? How will changes in ownership patterns and corporate structures affect tree breeding and forestry research? Other longer-term issues demand attention as well—particularly climate change. If climate change predictions are realized, the importance of plantation forestry will increase dramatically
within next 10 to 20 years. In the PNW, breeders must pay particular attention to maintaining forest health, including drought tolerance and resistance to native and introduced pests. Because native populations may become maladapted as climates change, we may need to replace native populations with better adapted seed sources using artificial regeneration. However, the information to do this wisely and confidently is not yet available for most species. To cope with climate change, we need sensitive systems for monitoring forest health, and the knowledge required to change seed source recommendations and breeding objectives. The ability to respond quickly will be enhanced by new genomic tools that will allow us to (1) monitor tree physiology at the gene level (i.e., via gene expression profiling), (2) characterize patterns of variation in

adaptive genes (i.e., via environmental and phenotypic association studies), and (3) practice marker-aided selection. Douglas-fir tree improvement and forest genetic research has been one of the best financial investments made by forest managers in the PNW, and may become one of the best environmental investments in the future.