Phyto-recurrent Selection: A Method for Selecting *Populus* and *Salix* Genotypes for Environmental Applications

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Short rotation woody crops (SRWCs) research began in 1968 at the U.S. Forest Service, Northern Research Station, Institute for Applied Ecosystem Studies (IAES) in Rhinelander, Wisconsin, USA. Genetics, physiology, and silviculture were at the forefront of research priorities, and the IAES became a national and global leader in SRWCs research and development. Given the vast amount of information learned during these decades coupled with the growing need for merging traditional intensive forestry with waste management, phytotechnologies research at the IAES began in the mid-1990s. The primary emphasis at the time was to evaluate the use of *Populus* and *Salix* as biological filters atop or adjacent to closed landfills. The practical implications for resources managers included being able to recycle and reuse municipal solid waste landfill leachate on-site to reduce the economic and ecological costs associated with treating the waste waters, along with maintaining regional environmental integrity of groundwater aquifers and nearby water bodies.

Early phytotechnologies research at the IAES involved testing the performance and phytoremediation capabilities of SRWCs in greenhouses and growth chambers, then progressed to field tests in tanks with engineered soil layers and ultimately field-scale plantations. Current research involves a combination of greenhouse and field tests. Adopting crop and tree improvement strategies used in forestry, horticulture, and agronomy, *phyto-recurrent selection* was developed to choose superior-performing genotypes for specific environmental applications. The method involves using multiple testing cycles to evaluate, identify, and select favorable clones based on the response of genotypes to variable wastewater chemistries and site conditions. Early cycles are relatively short and data collected are easy to acquire (typically done in the greenhouse or growth chamber), while later cycles require more time and resources to increase knowledge of genotypes advancing (typically done in the field). Less clones are tested as the complexity of the data increases, and multiple-trait selection strategies are used to evaluate the combination of complex phenotypic expressions regulated by quantitative traits. The ultimate goal is to deploy a combination of genotypes with improved phytoremediation potential over the original set of clones, as well as adequate genetic variation to guard against insect/disease outbreaks, changes in soil conditions (especially those induced by the wastewaters), and unfavourable genotype × environment interactions.

We will summarize these efforts by integrating results from eleven studies conducted during the last decade and a half in order to highlight the importance of phyto-recurrent selection for research studies and practical applications.