# Genomic Selection: Towards more Efficient, Financially Viable and Resilient Wood Production (GenoWood)

Bioeconomy aims at a society that strongly relies on renewable biological sources, while achieving economic growth efficiently and sustainably. In Finland, forest industry has a key role in bioeconomy. Demand for wood will be increasing, as well as demand for tailor-made trees with specific chemical and physical wood characteristics. In the near future, climate change and associated natural disturbances may negatively affect the productivity of forests. Increased wood production must further be combined with ecological and societal demands for biodiversity and multiple uses of forests.

Our goal in the project is to utilize novel genomic and phenotyping methods and examine the feasibility of conducting genomic selection in Nordic conifer species. The proposed research makes use of unique resources for Scots pine that have been developed in Finland during decades of research in forest tree genetics, breeding and biotechnology. Our project brings together research groups with complementary skills in molecular biology, population genetics and breeding, forest pathology, and economics.

Tree populations have large variation in many adaptive and economically important characteristics, enabling tree breeding based on natural genetic variation. Changes in the environment and in the use of wood put pressure to include new traits in breeding programs, for example resilience of trees against changing climate and resistance against pests and pathogens.

Genomic tools are increasingly being used for breeding of both animals and plants. Genomic selection uses genomewide markers to predict phenotypes. In order to associate genomic markers with phenotypes, we started in the summer 2018 an experiment where ca. 10,000 pine seedlings originating from different populations were grown in greenhouse conditions. Their growth rate was measured, as well as the timing of their budset, indicating preparation for wintering. A subset of the seedlings was subjected to freezing stress and their recovery was monitored by automatic color measurement. The experiment produced good quality phenotypic data that will be used for genomic selection analyses. In spring 2019, when the seedlings had overwintered successfully, 2000 seedlings were re-potted in the greenhouse and challenged with annosum root rot to measure their resistance, and needles were mechanically wounded to measure their chemical response. Variations in resistance of pine seedling populations in response to annosum infection was apparent. Susceptible seedlings had strong necrotic reactions as well as marked decreases in photosynthesis efficiency. There was a positive correlation between growth traits and necrotic lesions. Mechanical wounding of needles induced genes encoding enzymes responsible for synthesis of stilbenes, the same compounds that are responsible for hereditary decay resistance of pine heartwood. Unfortunately, the chemical profiling detected stilbenes in the needles of only few individuals.

In addition to greenhouse experiments on breeding material, Luke identified suitable field trials of the same families that will be phenotyped and genotyped during year 2020. The genotyping tool (SNP Array with about 50,000 SNPs) was developed using available sequence data from several earlier projects. Extensive bioinformatic analysis identified from these data high quality polymorphisms having high reproducibility, high technical quality, no paralogous regions and sufficient levels of variability. Using DNA isolated from needles, the goal is to score the 50,000 genetic markers for 500-700 individuals and to calculate their association to phenotypic traits. These data will be used for genomic prediction and examining potential of selection. The breeding population data are compared to a natural population using these same markers.

During the project we will analyze the economic (financial gains) and societal outcome (carbon balance) of present and future breeding for volume production (growth) and quality (decay resistant timber as an example). Economic analyses of genetically improved material providing monetary gains via increased growth and increased carbon intake will be published in the near future.

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