Joint master thesis of WSL and UZH

Using leaf spectroscopy in herbarium samples for species and hybrid identification in the European white oak (*Quercus* spp.) species complex

Supervision: Dr. Christian Rellstab (christian.rellstab@wsl.ch)
Swiss Federal Research Institute WSL, Ecological Genetics
Co-supervision: Dr. Tiziana Koch (tiziana.koch@geo.uzh.ch)
University of Zürich**,** Earth System Science
Faculty supervisor: Prof. Dr. Meredith Schuman
University of Zürich, Spatial Genetics of Ecosystems
Project leader: Dr. Aglaia Szukala
Austrian Research Centre for Forests (BFW), Ecological Genetics

The background: European white oaks (*Quercus* spp.) are thermophilic and often drought-tolerant forest tree species that will likely increase their abundance under climate change. In Europe, more than 25 white oak species can be found. These are often difficult to distinguish in nature, since many of them co-occur in sympatry, can hybridize, and bear high levels of phenotypic plasticity. From an adaptive perspective, hybridization may facilitate the transfer of beneficial gene variants involved in local adaptation between species through introgression. However, it is currently unknown to which extent adaptive introgression could reduce potential maladaptation to future climate change. Moreover, it is unclear how introgression impacts phenotypes – such as leaf morphological and physiological traits – tightly linked to ecological divergence and frequently used for species discrimination.

The project: The project HybOakAdapt studies the role of hybridization and introgression in climate adaptation in the white oak species complex, with a special focus on Austria and Southeastern Europe using whole-genome sequencing. The project's dataset includes the most widespread species, their hybrids and local subspecies along a climatic gradient – from relatively humid and cold conditions in Austria to dry and hot sites on the Black Sea coast. This will allow to quantify the extent of introgression, track its evolutionary dynamics over time and identify introgression hotspots in the genome with potentially adaptive functions. To clarify taxonomy and assess admixture and introgression, various leaf morphological traits will be assessed from herbarium specimens of the sequenced trees. Here, we add another set of phenotypic traits to the dataset: leaf spectroscopy traits. Leaf spectroscopy delivers spectral information from which important functional traits can be derived. In addition, different species should be distinguishable based on the whole spectrum, subsets of the spectrum, or by using, for example, vegetation indices. Currently, leaf spectroscopy of dried leaves from herbaria is an emerging topic, as this opens a huge data source for various fields, including global change research.

The dataset: We collected tissue (for sequencing) and herbarium samples (for phenotyping) from 1,205 trees across 74 white oak populations spanning Central (including Ticino) and Southeastern Europe, Türkiye, and Georgia. These trees belong to 12 white oak (sub-)species including their hybrids. All individuals are already sequenced. For each tree, we also assessed trichome traits and characterized leaf morphology (both important for morphological species assignment) and spectroscopy in a high-throughput phenotyping platform.

The research questions: In the current master thesis, you will work on the leaf spectroscopy dataset of the project and compare it to the genomic data, leaf morphology, and their resulting species assignments. We want to ask the following questions: How much variation in leaf spectroscopy traits can we find within and among white oak species? Which functional traits show large variation? Can we use leaf spectroscopy in dried herbarium samples to assign white oaks species and even identify hybrids?

The work: The thesis focuses on statistical analysis of large datasets, no field- and lab work is planned. The master student will process the leaf spectroscopy data and use them in various statistical analysis using classic indices and machine learning approaches. The output will then be linked to genomic, taxonomic and environmental data. Given the novelty of this work, we intend to submit at least parts of the thesis for publication in a peer-reviewed scientific journal Main working place is WSL in Birmensdorf, with regular visits to UZH and one visit to Vienna for a project meeting.

Required skills: Interest and background in forest trees, population genetics, geography, and/or remote sensing. Advanced skills in R and possibly experience with bash and high-performance computing, maybe even with genomic or remote sensing data. Good oral and written English skills. Structured, precise and independent way of work. Interest to work in an international collaborative project. Motivation to participate in the research group's activities (journal clubs, field work, etc.).

Interested? Get in contact with Christian Rellstab or Tiziana Koch.