The importance of genetic variation and phenotypic plasticity for climate adaptation in *Pinus sylvestris*: conclusions from a continent-wide study in Europe

José Alberto Ramírez-Valiente[1], Aida Solé[1], Raquel Benavides[2], Sandra Cervantes-Arango[3], Darius Danusevicius[4], Katrin Heer[5], Eduardo Notivol[6], Lars Opgenoorth[5], Tanja Pyhäjärvi[3], Outi Savolainen[3], Juan José Robledo-Arnuncio[1]
[1]Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria, Madrid, Spain; [2]Museo Nacional de Ciencias Naturales, Consejo Superior de Investigaciones Científicas, Madrid, Spain; [3]University of Oulu, Oulu, Finland; [4]Aleksandras Stulginskis University, Linkuva, Lithuania; [5]Philipps University Marburg, Marburg, Germany; [6]Centro de Investigación y Tecnología Agroalimentaria de Aragón, Zaragoza, Spain (josealberto.ramirezvaliente@gmail.com; aidasome@gmail.com; rbenavidescalvo@gmail.com; sandra.cervantesarango@oulu.fi; darius.danusevicius@asu.lt; katrin.heer@uni-marburg.de; enotivol@cita-aragon.es; opgenoorth@uni-marburg.de; tanja.pyhajarvi@oulu.fi; outi.savolainen@oulu.fi; jjrobledo@gmail.com)

Given the ongoing rapid climate change, the ability of species to respond to novel and changing environmental conditions is critical for long-term survival of populations. In forest trees, common gardens, reciprocal transplants and provenance trials have been widely used to assess the genetic composition and potential response to climate variation. However, such studies largely focus on juvenile or adult traits with little consideration on the early stages of development, which are crucial for niche regeneration. In this study, we explored the adaptive divergence and phenotypic plasticity in early fitness traits in *Pinus sylvestris* and examined the potential evolutionary response to the predicted future conditions of climate. We conducted a continent-wide series of experiments where 24.000 seeds from eighteen populations were established in common garden along a latitudinal gradient in Europe. In addition, geographically-closed populations with contrasting climates were included to evaluate the role of adaptation at small spatial scales. We monitored germination, survival, growth, phenology and ontogenic development over two years. Our results showed that populations largely differed in all studied traits and fitness components. Phenotypic differences were also observed between populations separated by a few hundred meters but with different altitudes. Interestingly, maternal families within populations exhibited a variation comparable with differences among long-distance populations. High plasticity to local environment was also found. Overall, our study suggests that climate has exerted strong selective pressures on *Pinus sylvestris*, driving the genetic differentiation of populations in traits important for fitness during the first stages of seedling development.

Production and quality of Caatinga dry forest seeds in a changing climate

Barbara França Dantas[1], Gilmara Moreira de Oliveira[2], Samara Elizabeth Vieira Gomes[3]
[1]Embrapa Semiárido, Petrolina, Brasil; [2]Universidade de Feira de Santana, Feira de Santanta, Brasil; [3]Universidade do Estado da Bahia, Juazeiro, Brasil (barbara.dantas@embrapa.br; gilmara_5@hotmail.com; samaraelizabethvg@yahoo.com.br)

The Caatinga dry forest has been experiencing, since 2010, the most severe drought ever recorded in the region, which has led to tree mortality, lack of seed production and/or quality and lower recruitment of seedlings. We aimed to correlate climate variations specifically, precipitation and temperature and seed quality of two important Caatinga species, Anadenanthera colubrina (Vell.) Brenan (Leguminosae – Mimosoideae) and Myracrodruon urundeuva Allemão(Anacardiaceae), in different harvest years from 2012 to 2018. Seeds were collected directly from mother-plants in a partially human-degraded Caatinga area. Anadenanthera colubrina seeds were sorted as small (Ø ≤ 1 cm) and large (Ø 1 cm). Seeds of both species of each harvest and/or classification were weighed and germinated for physiological quality evaluation. The climatic data were obtained by nearby agrometeorological stations. With *A. colubrina* seed size evaluation of four consecutive years and the mean, minimum and maximum annual precipitation and temperature, it was possible to observe that the variation in seed size in the lots may be related to the low precipitation and the high temperatures. Seeds of *M. urundeuva* showed improved germination percentage when produced in years with more rain. Physiological quality of seeds of both species were affected not only by rainfall volume but also by high temperatures. Thus, one can predict poor seed production and quality in a future climate at the Caatinga region, for which is predicted temperature increase of 4.5 ºC and 30% decrease in rainfall volume by 2100.

Genetic variation and evolutionary potential in a natural beech population

Marjana Westergren[1], Marko Bajc[1], Rok Damjanic[1], Domen Finzgar[2], Barbara Fussi[3], Filippos A. Aravanopoulos[4], Hojka Kraigher[1], Santiago C. González-Martínez[5]
[1]Slovenian Forestry Institute, Ljubljana, Slovenia; [2]University of Edinburgh, Edinburgh, United Kingdom; [3]Bavarian Office for Forest Seeding and Planting, Teisendorf, Germany; [4]Aristotle University of Thessaloniki, Thessaloniki, Greece; [5]BIOGECO, INRA, Bordeaux, France (marjana.westergren@gozdis.si; marko.bajc@gozdis.si; rok.damjanic@gozdis.si; d.finzgar@sms.ed.ac.uk; barbara.fussi@asp.bayern.de; aravanop@for.auth.gr; hojka.kraigher@gozdis.si; santiago.gonzalez-martinez@inra.fr)

Local survival of natural populations of forest trees relies on standing genetic variation and their capacity for adaptation to changing environments. Selection gradients, heritability, evolvability and selection response was studied in a natural population of European beech (*Fagus sylvatica*) in Slovenia. Adult trees (250), saplings (200) and 400 seeds obtained from 20 mother trees, were genotyped with 16 nuSSRs. Adaptive traits related to growth and phenology were assessed for all adult trees. Effective reproductive success, a fitness proxy, was estimated via parentage analysis. Log-linear models were used to compute female and male selection gradients correlating adaptive traits with fitness. Heritability was estimated using mixed models based on pedigrees reconstructed using nuSSRs. The study revealed skewed effective reproductive success, with few parents contributing to successful regeneration, and significant selection gradients. Strong directional selection was found for growth, with bigger trees having more offspring; also, trees with earlier phenology had higher reproductive output; finally, both early and late trees in terms of bud burst mothered less offspring. Heritability was low (albeit significant) for all traits except leaf senescence. Low phenotypic variance for phenological traits and moderate selection gradients resulted in low responses to selection, but that could be larger under increased selection pressure, as suggested by high evolvability for flowering and fruiting phenology (~20%). In conclusion, our study suggests some capacity of populations of forest trees to adapt locally; however, pace and intensity of climate change will determine whether such evolutionary responses will suffice for unassisted population survival.