



**COST Action FP1202**

**Strengthening conservation: a key issue for  
adaptation of marginal/ peripheral populations of  
forest trees to climate change in Europe (MaP-FGR)**



**ForMaP TRAINING SCHOOL and PhD COURSE (4 ECTS)**

**Analysis of genetic structure within and among populations  
with focus on marginal populations of woody species**

**18 January 2016 – 22 January 2016,  
Forest Genetics and Diversity (FGD), University of Copenhagen  
Forest and Landscape College  
Nødebo (Grib Forest), Fredensborg, Denmark**



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## LIST OF TRAINEES AND TRAINERS

	Name	Surname	Email	Country	Institution	Role
1	Sanja	Mrmić	sanjam@sumins.hr	Croatia	Croatian Forest Research Institute	Trainee
2	Elżbieta	Chomicz	E.Chomicz@ibles.waw.pl	Poland	Department of Mountain Forests, Forest Research Institute in Poland	Trainee
3	Perla	Farhat	perlafarhat@hotmail.com	Lebanon	Saint Joseph University	Trainee
4	Paloma	Torroba	paloma.torroba@gmail.com	Spain	INIA	Trainee
5	Nikolaos	Minadakis	niminad@gmail.com	Greece	Environmental Management and Natural Resources, Democritus University of Thrace	Trainee
6	Monika	Raskauskaite	m.raskauskaite@gmail.com	Lithuania	Aleksandras Stulginskis University	Trainee
7	Funda	Özdemir Değirmenci	ozfunda@metu.edu.tr	Turkey	Faculty of Art and Science Department of Biological Sciences METU	Trainee
8	José Carlos	Miranda García-Rovés	jc.miranda@upm.es	Spain	Technical University of Madrid	Trainee
9	Maria João	Magalhães Gaspar	mjgaspar@utad.pt	Portugal	Genetics and Biotechnology Department of the University of Tras-os-Montes e Alto Douro	Trainee
10	Mariaceleste	Labriola	mariaceleste.labriola@ibbr.cnr.it	Italy	Institute of Biosciences and BioResources, National Research Council, IBBR-CNR	Trainee
11	Patricia	Gonzalez Diaz	patricia.gonzalezdiaz@stir.ac.uk	Spain	School of Natural Sciences, University of Stirling	Trainee



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12	Alexandra Luísa	Ribeiro Dias	xana_dias@hotmail.com	Portugal	University of Trás-os-Montes and Alto Douro, Vila Real (Portugal)	Trainee
13	Alma	Piermattei	alma.piermattei@univpm.it	Italy	Dipartimento di Scienze Agrarie, Alimentari e Ambientali, Università Politecnica delle Marche	Trainee
14	Andrés	Flores-García	foga12@gmail.com	Spain	Universidad de Valladolid	Trainee
15	Asiye	Çiftçi	duru36@gmail.com	Turkey	Faculty of Art and Science Department of Biological Sciences METU	Trainee
16	Camilla	Avanzi	camilla.avanzi@gmail.com	Italy	University of Ferrara	Trainee
17	Çiğdem	Kansu (Çetiner)	kacigdem@metu.edu.tr	Turkey	Faculty of Art and Science Department of Biological Sciences Middle East Technical University	Trainee
18	Darius	Kavaliauskas	Darius.Kavaliauskas@asp.bayern.de	Lithuania	Bavarian Office for Forest Seeding and Planting (ASP) Aleksandras Stulginskis University, Lithuania	Trainee
19	Devrim	Semizer Cuming	dsemize@forst.uni-goettingen.de	Turkey	Georg-August University Georg-August University Goettingen and University of Copenhagen	Trainee
20	Elena	Ciocirlan	lia_ciocirlan@yahoo.com	Romania	Department of Forest Sciences (Laboratory of Forest Genetics and Dendrology)	Trainee
21	Eva	Ortvald Erichsen	eo@ign.ku.dk	Denmark	UCPH-IGN, Section for Forest, Nature and Biomass	Trainee
22	Francisca	Rodrigues dos Reis	franciscareis@bio.uminho.pt	Portugal	Departamento de Biologia   Centro de Biologia Funcional de Plantas Escola de Ciências Universidade do Minho	Trainee



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1	Erik	Dahl Kjaer	edk@ign.ku.dk	Denmark	University of Copenhagen	Director of the school
2	Gilles	Guillot	Gilles.GUILLOT@efsa.europa.eu	France	EFSA	Trainer
3	Albin	Lobo	alo@ign.ku.dk	Denmark	University of Copenhagen	Trainer
4	Jon	Kehlet Hansen	jkh@ign.ku.dk	Denmark	University of Copenhagen	Trainer
5	Valentina	Garavaglia	valentina.garavaglia@fao.org	Italy	FAO	Trainer



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## TRAINING SCHOOL AGENDA

	Monday	Tuesday	Wednesday	Thursday	Friday
08:00	Arrival	Breakfast	Breakfast	Breakfast	Breakfast
08:30		Introduction (EDK)	Population genetics and genetics of adaptation in marginal populations (EDK)	Departure for excursion Visit: BSO/common garden Field trials CSO/common garden (DCO/GFP/ALO/EDK/JKH)	Exercise on QG analysis (JKH)
09:00		Landscape genetics (GG)			
09:30		Coffee/Tea	Coffee/Tea		Coffee/Tea
10:00		Landscape genetics (GG)	Student discussion of papers (EDK/JKH)		Student discussion of papers (EDK/JKH)
10:30		Landscape genetics (GG)			
11:00		Landscape genetics (GG)			
11:30		Lunch	Lunch	Lunch	Lunch
12:00		Landscape genetics exercises (GG)	Use of ecophysiological tools (ARE)	Genetic analysis - ash case (EDK)	Scale of adaptation and assisted migration (EDK)
12:30			Genetic management and use of native populations in DK (DCO)	Exercise on QG analysis (JKH/ALO)	Discussion and evaluation
13:00		Coffee/Tea	Coffee/Tea	Coffee/Tea	Coffee/Tea
13:30		Landscape genetics exercises (GG)	Genetic analysis common garden trials (JKH)	Exercise on QG analysis (JKH/ALO)	Departure
14:00		Follow-up			
14:30		Fresh air - walk and talk in forest	Fresh air - walk and talk in forest	Fresh air - walk and talk in forest	
15:00		Dinner	Dinner	Dinner	
15:30		Participants present their research (EDK)	Participants present their research(EDK)	Participants present their research(EDK)	
16:00					
16:30					
17:00					
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18:30					
19:00					
21:00					



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The training School has been organized in collaboration with the University of Copenhagen and hosted by the Forest and Landscape College (<http://ign.ku.dk/english/about/organisation/sections/forest-landscape-college/folder-about-the-forest-college/welcome-folder-forest-college.pdf>).



*Location of the Training School (Forest and Landscape college)*

Lectures on the topic “*Analysis of genetic structure within and among populations with focus on marginal populations of woody species*” were covered by TS trainers (G. Guillot, E. Dahl Kjaer, A. Raebild, D.C. Olrik, J. K. Hansen (with the support of A. Lobo), G. F. Proschowsky) experts on genetics, forest reproductive material management, genomics of adaptation, ecophysiology. In detail the topics covered in the lectures and according to the program of the Training School were the following:

- **Landscape genetics (G. Guillot)**

What is landscape genetics?; spatial clustering model(s) for the analysis of population genetic structure; from clusters to hybrid zones; a unifying model" for the analysis of genetic, phenotypic and spatial data; causal modelling" of genetic or phenotypic differentiation: dismantling the Mantel tests; detection of correlation between genotypes and environmental variables; geographical assignment from genetic data; computer exercises.

- **Population genetics and genetics of adaptation in marginal populations (E. D. Kjaer)**

Definition of population; Hardy-Weinberg equilibrium; heterozygosity; non-random mating; selfing species; cryptic population structure; linkage equilibrium in outcrossing populations; linkage equilibrium/disequilibrium; genetic differentiation and loss of diversity; random



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genetic drift; gene flow; genetic differentiation; Drift versus selection – and implication of gene flow; population sizes; measure of genetic diversity; provenance trials, ecophys. tests, candidate genes; randomized replications; estimate variance components; genotype x environment interaction; estimate variance components; genetic differentiation – quantitative traits.

- **Gene conservation of trees and shrubs in Denmark (Ditte C. Olrik)**

Conservation strategies. EUFORGEN and EUFGIS; challenges – species in Denmark; conservation objectives (in situ and ex situ, gene ecological zones, gene isolation flow); nature, biodiversity and subsidy; conservation through use; examples (*Corylus avellana*, *Picea abies*, *Fraxinus excelsa*, *Pinus sylvestris*); seed orchards – ex situ.

- **Scale of adaptive patterns and potential response (E. D. Kjaer)**

Scale and speed of adaptation: lessons from provenance trials and landrace formation; The case of *Picea sitchensis* in Denmark; genetic differentiation and loss of diversity; the case of *Malus sylvestris*; scale of adaptive patterns and potential response (Danish case); genetic variation within populations: what is sufficient?; genetic management.

- **Use of ecophysiological tools (Anders Raebild)**

Frost damage; assessing frost damage; determination of frost-tolerance genotype; Drought stress to trees; isohydric species/anisohydric species; assessing the effects of drought stress; lethal dose of drought (LD50); the control of water level in pot experiments.

- **Genetic analysis of common garden tests (Jon Kehlet Hansen)**

Quantitative genetics models – from one to many loci – distribution of values, midparent value, population mean and genotypic values; general and specific combining ability; estimation of variance components; quantitative genetic concepts – genotype-environment interaction; estimation of response to selection; introduction to exercises.

- **An example of novel fungal disease: *Fraxinus excelsior* versus *Hymenoscyphus fraxineus* (E.D. Kjaer)**

The pathogen – spread and disease symptoms. Clonal trials and progeny trials; response to inoculation; level of narrow sense heritability and GxE.

- **Practical exercises (Jon Kehlet Hansen with the support of Albin Lobo)**

## Trainees' paper discussions

Before the training school, selected papers and background materials were shared with trainees. They were asked to read and discuss them in dedicated sessions during the week.

- Chapter 5, 6, 7 and 8 in Eriksson et al 2013: Genetics Applied to Forestry, p. 55-128.



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- Aitken et al., 2008. Adaptation, migration or extirpation: climate change outcomes for tree populations. *Evolutionary applications*, Vol.1, issue 1 (<http://onlinelibrary.wiley.com/doi/10.1111/j.1752-4571.2007.00013.x/pdf>)
- Koskela et al., 2007. Climate change and forest genetic diversity. Implications for sustainable forest management in Europe (<http://www.euforgen.org/fileadmin/bioersivity/publications/pdfs/1216.pdf>)
- Kvaalen H., Øystein J., 2008. Timing of bud set in *Picea abies* is regulated by a memory of temperature during zygotic and somatic embryogenesis. *New phytologist*, Volume 177, Issue 1 (<http://onlinelibrary.wiley.com/doi/10.1111/j.1469-8137.2007.02222.x/abstract>)
- Dahl Kjær et al. 2011, Adaptive potential of ash (*Fraxinus excelsior*) populations against the novel emerging pathogen *Hymenoscyphus pseudoalbidus*. *Evolutionary applications*, Vol. 5, Issue 3 (<http://onlinelibrary.wiley.com/doi/10.1111/j.1752-4571.2011.00222.x/abstract>)

Trainees were also asked to present their research activity and interests in informal sessions after dinner during the week. In this occasion each trainee could present his PhD topics and obtain interesting comments and suggestions from other colleagues and trainers.

## FIELD TRIP

In the morning of January 21st, 2016 a field trip was organized to visit a field trial, the local arboretum and a common garden.

- **Ash field trial in Hørsholm**



Design and assessments of common garden type of trials were discussed, and the species and disease symptoms analyzed during the exercises were introduced. Results from quantitative analysis of the trials were presented and discussed. Also, finding from a bioassay based on controlled inoculations were presented and discussed.

- **Arboretum**

The experimental nursery of the University of Copenhagen was visited and ongoing activities related to the course were presented. A special emphasis was made on the



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cooperation between research in and management of forest genetic resources using *Fraxinus* as an example. A brief visit was paid to the collection of more than 2,000 taxa of woody plant species growing in the Arboretum, and research into two aspects were presented: (1) host range and eco-evolution between host and pathogens, (2) hybridization and introgression



- ***Crataegus monogyna* common garden in Humlebaek**

The purpose was to present and discuss how improved understanding of local adaptation is implemented into applied seed procurement and gene conservation in Denmark. A clonal seed source belonging to the Danish Nature Agency was therefore visited. This is one of the seed sources providing seeds of *Crataegus monogyna* for planting activities in Denmark. It is established with grafting of 51 putative native individuals collected from a number of different populations. The visited clonal seed orchard has an added function as field trial/common garden representing the Western Danish gene pool of *Crataegus monogyna*. The material was collected and grafted in winter 2001/2002 and planted in 2003.

*C. monogyna* is one of three Hawthorns species which are considered native to Denmark. The other two species are *C. laevigata* and *C. rhipidophylla*. The taxonomy of the genus *Crataegus* is complicated and has been revised a number of times. Challenges include hybridization between species, and polyploidy of many *C.* species. Not only does this complicate the taxonomy and genetic analyses, but it also makes identification of the Danish species difficult, because polyploidy potentially can disguise and accumulate introgression better than diploids. Furthermore, all three species have a high degree of phenotypic plasticity in eg. vegetative and floral characters, with overlap between species. The great challenge concerning mobilization of the gene pool of the *C.* sp. has therefore been to identify species limits and non-introgressed individuals. As there are no available molecular tools to provide a species specific test, and test of species integrity has therefore been based on morphological and phenotypic data.

The concept of effective population size was discussed based on observations in variation among clones in fecundity (fruit development). The analysis from a previous year lead to an estimate of  $N_e=33$ , i.e 66% of the census number  $N=51$ .



Copenhagen, January 25, 2016

Training School Director

A handwritten signature in blue ink, which appears to read "Erik Dahl Kjaer". The signature is stylized and includes a checkmark-like flourish at the end.

Erik Dahl Kjaer



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