COST Action FP1202
Strengthening conservation: a key issue for adaptation of marginal/ peripheral populations of forest trees to climate change in Europe (MaP-FGR)

2014 TRAINING SCHOOL

Adaptation and evolution of marginal and peripheral populations of forest trees and the leading, altitudinal and rear edges of species distribution

REPORT

7 July - 11 July 2014,
Jaca, Spain

LIST OF TRAINEES AND TRAINERS

	Surname	Name	Email	Institution	Country	Role
1	Castaldi	Cristiano	cristiano.castaldi@entecra.it	Forestry research centre (CRA-SEL) (Arezzo, Italy)	Italy	Trainee
2	Dias	Alexandra	xana_dias@hotmail.com	University of Trás-os-Montes and Alto Douro (Vila Real)	Portugal	Trainee
3	Farsakoglou	Anna-Maria	annamariafa91@gmail.com	Aristotle University of Thessaloniki (Thessaloniki)	Greece	Trainee
4	Garcia	Alfredo	alfredo.garcia@urjc.es	Universidad Rey Juan Carlos (Mostoles)	Spain	Trainee
5	Gaspar	Maria	mjgaspar@utad.pt	University of Trás-os-Montes e Alto Douro (Vila Real)	Portugal	Trainee
6	Guardiola Egea	Nuria	nguardiola89@gmail.com	University of Lleida	Spain	Trainee
7	Hajrudinovic	Alma	alma.hajrudinovic@gmail.com	Faculty of Forestry University of Sarajevo (Sarajevo, Bosnia and Herzegovina)	Bosnia and Herzegovina	Trainee
8	Hebda	Anna	a.hebda@ur.krakow.pl	University of Agriculture in Krakow	Poland	Trainee
9	Hernandez	Enrique	enrique.hernandez.tecles@gmail.com	CIFOR-INIA (MADRID, Spain)	Spain	Trainee
10	Housset	Johann	johann.housset@gmail.com	Centre d'étude de la forêt (Montreal, Canada)/Université Montpellier 2	France	Trainee
11	Huotari	Tea	Tea.Huotari@metla.fi	METLAB (Helsinki)	Finland	Huotari
12	Likus	Justyna	justynalikus@gmail.com	University of Agriculture in Krakow (Kraków)	Poland	Trainee
13	Lobo	Albin	albinlobo@gmail.com	University of Copenhagen (Frederiksberg)	Denmark	Trainee
14	Lopez	Xose	xlgoldar@mbg.csic.es	Misión Biológica de Galicia (Salcedo (Pontevedra)	Spain	Trainee
15	Navarro Ruiz	Pablo	navarroruiz@gmail.com	Institute for Forest Genetics (Großhansdorf)	Germany	Trainee

16	Pinto	Gloria	gpinto@ua.pt	University of Aveiro (Aveiro)	Portugal	Trainee
17	Possen	Boy	boy.possen@metla.fi	The Finnish Forest Research Institute (Punkaharju)	Finland	Trainee
18	Martin	Ruth	martin.ruth@inia.es	Forest Research Centre (CIFOR-INIA) (Madrid)	Spain	Trainee
19	Tsolakidis	Panagiotis	ptsolak@for.auth.gr	Aristotle University of Thessaloniki (Thessaloniki)	Greece	Trainee
20	Volekova	Michaela	michaela.volekova@gmail.com	Technical University in Zvolen (Zvolen)	Slovakia	Trainee
1	**Notivol Paíno**	**Eduardo**	**enotivol@aragon.es**	**Centro de Investigación y Tecnología Agroalimentaria (CITA) Departamento de Innovación y Nuevas Tecnologías**	**Spain**	**Trainer and TS coordinator**
2	Alia Miranda	Ricardo	alia@inia.es	Centro Investigacíon Forestal – CIFOR, Madrid	Spain (TS Coordinator)	Trainer
3	Climent	José	climent@inia.es	Centro Investigacíon Forestal – CIFOR, Madrid	Spain	Trainer
4	Cavers	Stephen	scav@ceh.ac.uk	NERC Centre for Ecology and Hydrology, Edinburgh	England	Trainer
5	Grivet	Delphine	dgrivet@inia.es	Centro Investigacíon Forestal – CIFOR, Madrid	Spain	Trainer
6	Vendramin,	Giovanni Giuseppe	gg.vendramin@gmail.com	Plant Genetics Institute - National Research Council, Florence	Italy	Trainer
7	Fady	Bruno	bruno.fady@avignon.inra.fr	Institut National de la Recherche Agronimique, INRA, Avignon	France	Trainer

TRAINING SCHOOL AGENDA

COST Action FP1202: Strengthening conservation: a key issue for adaptation of marginal/ peripheral populations of forest trees to climate change in Europe (MaP-FGR)

Universidad Zaragoza

ANNUAL TRAINING SCHOOL 2014: Adaptation and evolution of Marginal-Peripheral populations of forest trees at the leading, altitudinal and rear edges of species distribution (7 July - 11 July 2014, Co-organized with the University of Zaragoza – Spain Venue: Universitary residence of Jaca)

	Monday (July 7, 2014)	Tuesday (July 8, 2014)	Wednesday (July 9, 2014)	Thursday (July 10, 2014)	Friday (July 11, 2014)
9.00-10.30	Welcome Introduction to the TS Program of the TS Roundtable presentation of trainers/trainees. Opening and presentation of COST Action	Genetic resource conservation in forests at the northern edge: factors shaping genetic diversity and population structure I (Stephen Cavers)	Design a genetic resource conservation strategy for a marginal northern tree population (Stephen Cavers)	FIELD TRIP	Practical exercise on Management of MaP reproductive materials (Ricardo Alia & Eduardo Notivol)
10.30-11.00	break	break	break		break
11.00-13.00	GENETIC CONSECUENCES OF BEING AT ECOLOGICAL & GEOGRAPHICAL MARGINS (Bruno Fady)	DELIMITATION OF MaP POPULATIONS FROM THE ECOLOGICAL POINT OF VIEW (Julian Gonzalo) Ecological niche model: Application for analysis of MaP populations dynamics	Strategies for the conservation of FGR in Europe: The importance of marginal pops (Bruno Fady)		Presentation of most recent study cases on adaptation and evolution of MaP- FGR (Delphine Grivet)
13.00-14.00	lunch	lunch	lunch		lunch
14.00-16.00	Presentation of researches of the trainees (10' each)	Practical use of software for data analysis (Beppe Vendramin)	What can molecular markers tell us about demography & slection (Beppe Vendramin)	Phenotypic plasticity and integration in forest tree populations (Jose Climent)	Design of experiments and adaptive variation analyses II (Eduardo Notivol)
16.00-16.30	break	break	break	break	break
16.30-18.00	Presentation of researches of the trainees (10' each)	Design of experiments and adaptive variation analyses I (Eduardo Notivol)	Open discussion Questions of trainees	Management of MaP reproductive materials and related legislation (Ricardo Alia & Eduardo Notivol)	Open discussion, evaluation and closing

The training School has been organized in collaboration with the University of Zaragoza on 7-11 July 2014 in Jaca (Spain). The TS was hosted by the University Residence in Jaca (http://www.unizar.es/resijaca/html/inicio.php) and included in the agenda of summer courses.

Lectures on the topic ''Adaptation and evolution of marginal and peripheral populations of forest trees and the leading, altitudinal and rear edges of species distribution'' were covered by TS trainers (E. Notivol, B. Fady, G. Vendramin, S. Cavers, R. Alia, D. Grivet, J. Climent). In detail the topics covered in the lectures and according to the program of the Training School were the following:

- **"Genetic consequences of being at the ecological and geographical margins", B. Fady**

Definition of marginal and peripheral population; definition of rear, leading margin and disjunct population. Definition of geographical, ecological and man-made margins. Leading and trailing margins: genetic implications; the abundant center paradigm; the argument for low genetic diversity; the genetic diversity of Norway spruce in Scandinavia; genetic diversity of trailing edge populations (species); diversity in central and peripheral populations is similar; type of marginality effects gene diversity: disjunct *vs* marginal populations; gene diversity in Europe is lower at geographic margins, but not always; stable (rear) edge populations have higher gene diversity; genetic diversity in rear edge populations is spatially organized in the Mediterranean refugial zone; organization of genetic diversity of trailing edge populations depends on ecological and evolutionary factors, on their life history traits, on their ecological requirements, on their evolutionary history; margins: genetic implications; margins at the trailing edge: the argument for adaptation; geographic margins: genetic implications under the abundant center paradigm; margins at the trailing edge: the argument for decreasing genetic diversity over time as climate change; margins and the trailing edge: genetic implications; an example of population density decrease at the trailing edge in the French Alps; are plants locally adapted? A meta-analysis of local adaptation in plants; local adaptation may be rare at the receding edge. Evolvability towards climate change unlikely because of inefficient selection; gene flow can promote local adaptation at the receding edge; trailing edge populations of the intertidal seaweed *Fucus serratus* are least adapted to temperature increase; trailing edge populations may harbor increased phenotypic plasticity towards global warming than core or leading edge populations; trailing edge populations are already found in hotter than optimal climates; lowering density increases selfing: an effect of the rear-edge; lower population density decreases seed set and increases selfing events in *Abies alba* at the trailing edge; effective adult tree density must be very low for random mating to be disrupted; local adaptation may not be equally tested for all traits; the argument for hybridization as a rescue factor; congeneric contact zones likely in the future; is this blurry picture linked to a confusion between geographic and ecological margins?

- **Genetic resource conservation in forests at the northern edge: factors shaping genetic diversity and population structure, S. Cavers**

The northern margin; factors particular to populations at the northern edge; drivers shaping genetic resources; case study species : Scots pine (*Pinus sylvestris*); context; assessing historical and evolutionary drivers of genetic variation; a) demographic history; differentiation from demographic scenario testing continental European populations; diversity and neutrality in Scotland *vs* continental populations; linkage disequilibrium; origins of Scottish populations; demographic scenario testing; recent works: i) genetic diversity – molecular; ii) genetic diversity – phenotypic; b) phenotypic variation; applying the phenotypic approach for studying adaptation; experimental approach in Scottish *P. sylvestris*; variation in needle morphology; variation in needle morphology across Scotland; variation in needle physiology; variation in carbon isotope discrimination; variation in needle physiology – time of spring bud burst; variation in adaptation to extreme environments, chlorophyll fluorescence measurements; response of populations to low winter temperatures, to imposed drought, to imposed flooding.

- **FAO Silva Mediterranea/Cost Action FP1202, V. Garavaglia**

A short presentation was given to clarify the link between FAO *Silva Mediterranea* and Cost Action FP1202 Map FGR. The main structure and role of the *Silva Mediterranea* Committee and the Collaborative Partnership on Mediterranean Forests were presented.

- **Forest trees, climate changes, Mediterranean ecosystem/species, genetic structure (including spatial structure), demography selection, Bayesian clustering ABC (DIYABAC), G.G. Vendramin**

FORESTERRA project, The limits of plasticity: predicted effect of climate change on tree distributions; predition for the Mediterranean; the southern European context; local adaptation in Mediterranean trees?; the Mediterranean forest: a threatened hotspot of diversity; some genetic particularities of Mediterranean forests; what can trees do to cope with climate change ?; migration potential; what is phylogeography?; phylogeographic analysis; chloroplast and mitochondrial DNA markers; complex system that results is significant population structure and opportunities for local adaptation; a multispecies population genetic & phylogeographic survey of trees and shrubs across Europe; CYTOFOR project; level and distribution of the diversity can be strongly influenced by human activities.....i.e. *Castanea sativa* and *Pinus pinea*; database of genetically depauperate plants; fragmented distribution range; mating system, ability to disperse seeds; traditional common garden experiments for Mediterranean trees; molecular approaches based on putatively functional markers; selecting candidate genes to drought tolerance; demography and selection in Aleppo and maritime pines; Correlation with environmental variables at the wide-range scale in pine; SNP-environment correlations for heat-shock factor rhsf2; candidate-gene SNPs can predict climate maladaptation in an outcrossing Mediterranean conifer; 23 SNPs correlated with climate variables; common garden in harsh climate (Cálcena); design of

384-SNP genotyping array (Illumina VeraCode technology); CRIEC candidate genes (229 amplicons in Pinus *brutia* and *Pinus halepensis*); microsatellites; SNPs; Nucleotide diversity patterns of stress and phenology candidate genes along a *Fagus sylvatica* altitudinal gradient; along an altitudinal gradient; strategy for selecting candidate genes; levels of nucleotide diversity in *Fagus sylvatica*; altitudinal gradients in Aleppo pine: genetics meets ecophysiology; neutral and adaptive genetic variation in silver fir (*Abies alba* Mill.) populations located in the southern peripheral species distribution range; genotype - Environment Association test; resequencing in Conifers (CRIEC initiative); full transcriptome sequencing of *Taxus baccata* using Illumina HiSeq 2000; full genome and transcriptome sequencing; genetic structure of populations is related to LHT (e.g. mating system). Can the genetic structure of plant populations be predicted from species' life history traits?; Strong population genetic structure, recent demographic decline and selection shape diversity of taxol-related genes in European yew (*Taxus baccata* L.).

- **"Design of experiments (analyzing the adaptive variation)", E. Notivol**

Tool for addressing analytical problems without fixed laws; plant material or treatment evaluation; planning of an experiment, stages, principles; operational limiting factor; elementary designs; incomplete box (and design efficiency); examples of software: AZARsXXI.exe, CyCDesigN.

- **"Genetic conservation of marginal populations: the European strategy", B. Fady**

The goals of *in situ* conservation; how to correctly sample the genetic diversity of a species? Considering demographic history; Populations have different adaptive properties in addition to demography and evolutionary history; how to correctly sample the genetic diversity of a species? Considering adaptation in addition to demography and evolutionary history; integrating approaches for a science-based sustainable in situ conservation strategy; one example of genetic resource conservation network in France: *Abies alba*; the actual and current network of FGR conservation of *Abies alba* in France; the current network of FGR conservation of *Abies alba* in France: gaps to fill; the evolutionary history of *Abies alba* in western Europe and the Pyrenees; what must a Conservation Unit guarantee?; how must a Conservation Unit be managed? A legally binding charter; the French register of conservation units for widely occurring species; how must a Conservation Unit be managed? A legally binding charter; the French register of conservation units for widely occurring species; what is done at national level can be done range-wide: an example with *Pinus pinaster*; *in situ* conservation of forest genetic resources (FGR): the pan-European dimension; Euforgen Phase IV (2010-2014); why an ex situ approach?; an example of species under pandemic risk: *Ulmus* sp.; an example of species where risks lie on habitat: field hedges; examples of species where risks lie on habitat: Ensligh walnut; example of a species where risks lie on habitat degradation and genetic pollution; an integrated FGR conservation and sustainable use program for Salzmann pine in France; geography and taxonomy of black pine; geography and taxonomy of black pine: marginal populations; uniqueness, risks and protection needs; the objectives of the «Salzmann» project: *ex situ* collection of autochthonous pines; finding

autochthonous Salzmann pines in France; sampling for grafting and genetic monitoring; plant material for grafting and conservation; storing seeds; grafting: a high performance cloning technique; retracing the evolutionary history of Salzmann pine and black pine with uneven success rates for old material; the DNA barcode approach: black pines are a homogeneous genetic group; the genetic structure of black pines: two main phylogenetic groups; focusing on 7 populations using nSSRs and SNPs at adaptive genes; the genetic structure of black pines: two main phylogenetic groups; hybridization in France : fiction or reality?; considering adaptation in addition to demography and evolutionary history. Drift or local adaptation?; the evolutionary history and the genetic diversity of key functional traits in *Pinus nigra*: consequences for the conservation of *Pinus nigra salzmannii*; conserving genetic resources of marginal populations: challenges that remain; a need to include marginal populations in genetic.

- **FGR in the Global Action Plan of the UN, C. Besacier**

Committee on Forestry, Regional committees; FAO - *Silva Mediterranea;* Key findings from the III Mediterranean forest week (Tlemcen, March 2013); Tlemcen declaration; State of Mediterranean forests 2013; State of World Forest Genetic Resources 2014, the Global Action Plan.

- **"Regulation of forest reproductive material of marginal and peripheral populations", R. Alia**

Use of forest reproductive material in forestry procurement of forest reproductive material; deployment of forest reproductive material; application of the Directive; EN regulation scheme – Directive 1999/105Ec; principle of the EU Directive; conservation of genetic resources: restrictions (Article 17); importance of genetic variation among regions; regions of provenance: European scale; base material: seed source, seed orchard; base materials; European list; base and reproductive material in MaPs; MaPs: usually under not very predictable conditions; transfer of reproductive material in MaPs.

- **"Phenotypic plasticity and integration in forest tree populations", J. Climent**

Definition of plasticity; phenotypic plasticity; ontogenetic effects; the role of allometry and ontogeny; epigenetics and maternal effects; plasticity and stability; specific and general adaptation; plasticity indexes; quantitative genetics of plasticity; fitness correlates of plasticity; phenotypic integration; LHTs trade-offs: costs of reproduction; population differentiation for Life History integrated phenotype.

- **"Most recent study cases on adaptation and evolution of marginal-peripheral populations of forests ", D. Grivet**

Reviews on forest tree adaptation at peripheral/marginal/rear edge margins; phenotypic plasticity vs genotypic adaptation; centre-periphery hypothesis; gene flow in the context of climate change;

study cases (methods and software application): i) altitudinal or latitudinal clinal variation of allelic frequencies; ii) Detecting FST outliers.

- **"FRM strategies: practical exercises", E. Notivol**

Ecological information about the environment where the scots pine populations live are presented at European level. This information is derived from the climatic model "Worldclim" and after statistical elaboration all the regions of provenance are plotted and grouped by similar ecological conditions. Some extra data from molecular markers for selected populations are presented as well. The questions to be discussed by groups and further idea-sharing session were about singularity of the populations, priorities for their conservation and what kind (and from where) of forest reproductive materials should be used for reforestation purposes in these populations.

Trainees' Workshop

On the 11th of July, half a day was dedicated to give the trainees the opportunity to present an overview of their research, research achievements and interests in 10' presentations that were followed by short discussion and questions. During the sessions the trainees had the opportunity to discuss issues related to their research with the trainers and get advice on how to proceed more efficiently with their work and also receive questions regarding their research from the their colleagues:

1. ''Trees for future forests'', Albin Lobo;
2. ''Ecology and management of *Pinus nigra* on mountainous areas'', Alexandra Dias;
3. "AdAptA project: population size and population origin for marginal/peripheral populations", Alfredo Garcia Fernandez;
4. "Genome size and morphological characterization of some *Sorbus* species in Bosnia and Herzegovina", Alma Hajrundinovic;
5. "The national forest program in Poland and activities of department of Genetics and Forest Tree Breeding", Hanna Hebda;
6. "Genetic SSR variation of natural oriental plane tree populations (*Platanus orientalis*) in Greece and comparative analysis with the evergreen mutation variety (*Platanus orientalis* vs *cretica*)", Anna-Maria Farsakoglou;
7. "FORGER Towards the sustainable management of forest genetic resources in Europe", Tea Houtari;
8. "Introduction to RESILFOR and BIODATI projects and PhD thesis", Cristiano Castaldi;
9. "Presentation of the PhD thesis – diversity approaches", Henrique Hernandez Tecles;
10. "Plant biotechnology and plant performance under global environmental changes: focus on forest tree species", Gloria Catarina Pinto;
11. "Growth variations and adaptation potential of *Thuja occidentalis* leading edge marginal populations in response to climate change", Johann Housset;

12. ”Genetic variations in populations of the hybridogenous complex *Abies alba – A. borisii-regis – A. cephalonica*'', Michaela Volekova;
13. “Adaptive and reproductive behavior of *Prunus avium*'s Spanish clones selected for timber: phenology, growth and conformation”, Nuria Guardiola;
14. ”Study of the adaptation, growth and forest management of European Beech Provenances growing in the Spanish Pyrenees”, Pablo Navarro Ruiz;
15. “Reproductive strategies: adaptive significance in relation to alternative life-history traits in Iberian pines”, Ruth C. Martin Sanz;
16. ”Defensive strategies in conifers”, Xosé Lopez Goldar;
17. “Differences between Silver fir birch trees in traits driving growth and acclimation”, Boy Possen:
18. “Response to environmental stress and adaptation of stress in the conditions of marginal-technosols conditions”, Justyna Likus;
19. “Genetic analysis of *Pinus heldreichii* Ant. populations. Phylogenetic relationships in the species”, Panagiotis Tsolakidis.

FIELD TRIP

On Thursday the 10th a field trip was organized to visit and to check some concepts presented in the training school. The destination was the Abies alba stand in “San Juan de la Peña” protected site. The characteristics of this forest made the visit very suitable for the purpose. The forest includes a large stand in with a healthy status and good natural regeneration. The location of this population (the second southern population of the distribution area of the species) makes this population special from the point of view of peripherally and marginality for being in the rear edge of the distribution. The wild life of the area increases the value of the site with their colonies of vultures (griffon and bearded), deers and wild boars. The surrounding and scattered species included in the forest provide a very nice example for practical demonstration of the topics dealt in the training school too. The excursion included a 3 Km walking and return through the forest up to the summit of San Salvador where a magnificent view of the Pyrenees range and southern lowlands could be enjoyed. Finally the visit ended with a cultural-historical visit to the Xth century monastery of San Juan de la Peña, a true jewel of the Romanesque period.

Jaca, Spain, 17th July 2014

Eduardo Notivol Paino
Training School Coordinator
Centro de Investigación y Tecnología
Agroalimentaria (CITA) de Aragón
Gobierno de Aragón