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Marginal/peripheral populations of forest tree species and their conservation status: report for southeastern Europe

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Abstract - The Southeastern Europe, which is usually known as Balkan Peninsula, harbours a vast number of plant species among which a great number of relict and endemic ones. This region was one of the main areas in Europe where plant species found shelter in refugia and survived during the last glaciation. These refugia were the source areas for the postglacial colonization of many forest tree species. Human impact has been reported in the region since antiquity resulting in deforestation and fragmentation of forests. Marginal/peripheral (MaP) populations could be identified for many forest tree species occurring in the region. However, detailed information about MaP populations is restricted to few cases. Most of the MaP populations identified by FP1202 experts are not located in protected areas. Thus, approximately 27 % of the MaP populations are included in Natura 2000 sites, and only one out of the four reported populations is included in a genetic conservation unit. Many MaP populations (40%) are registered as seed stands and only 14% are included in EUFGIS database. Conservation of forest genetic resources, including MaP populations, is a component of sustainable management of forests in many countries of the region.

Keywords - Forest genetic resources; forest tree marginal populations; MaPs; marginality; Cost Action FP 1202 MaP FGR.

Geographical characteristics of the region

Extension and borders and main characteristics

The Southeastern Europe region, which is usually known as Balkan Peninsula, following its most extensive definition, is surrounded by the Adriatic Sea, the Mediterranean Sea, the Marmara and the Black Seas, while its northern borders are defined by the line stretching from the northernmost point of the Adriatic to the northernmost point of the Black Sea. Its flora is characterized by a vast number of species among which a great number of relict and endemic ones; the most species rich country is Greece, harbouring around 5 800 species. Data reported for nine countries (Bosnia & Herzegovina, Bulgaria, Croatia, Greece, Montenegro, Serbia, Slovenia, Romania and Ukraine) were considered in this regional report.

Orography

Most of the South-eastern Europe region is covered by mountain ranges stretching from northwest to southeast. The main ranges are the Balkan Mountains in central Bulgaria, the southern Carpathians in Romania, the Rhodope mountains in southern Bulgaria and northern Greece, the Dinaric Alps in the western part of the region, the Šar mountains in the area of Kosovo, Albania and F.Y.R.O.M. and the Pindos mountains stretching from southern Albania, close to the Greek-Albanian borders, to central Greece.

Human impact

Human impact has been reported since antiquity for all the South-eastern Europe countries, resulting mainly in fragmentation of forests and deforestation largely due to extensive logging, forest fires, long lasting wars, overgrazing and land use changes (Beus 1984). Large lowland areas in all countries have been cleared for cultivation of agricultural crops and a notable part of the hilly and mountainous areas have been intensively grazed by sheep, goats and cattle, resulting in forest deterioration and fragmentation. Furthermore, water resources (i.e. rivers, lakes) have been regulated, swamps were dried out and hence conditions for the development of large cities were set. In great part of the region the native vegetation has been lost due to the above mentioned reasons, while soil has eroded in many cases due to human activity.

Geographic barriers to gene flow

The main mountain ranges across the region are stretching from a northwest to a southeast direction and thus may represent a natural barrier for the migration of many forest tree species northwards. For instance, common beech (*Fagus sylvatica*) originating from areas like eastern Alps and possibly south

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Moravia (Magri et al. 2006) colonized the southern Carpathian mountains, the natural border between South-eastern Europe and Central Europe. As reported by Hewitt (1999), refugia in the Southeastern Europe (Balkan peninsula) are confirmed as distinct major refugia and have provided Northern European colonization for most species, including forest ones, except when some more eastern or western invasions blocked their advance. When it comes to white oak species (*Quercus* spp.), it appears that they migrated along the canyons of large rivers in the western part of the region (Slade et al. 2008).

Ecological aspects

Climatic characteristics of the region - availability of databases and maps at regional level

The climate of the region ranges from temperate-continental inland to a Mediterranean one along the Adriatic and Aegean coasts. In general, winters are frosty and snowy, summers are hot and dry in the northern part of the region and in the mountainous areas. In the southernmost part the climate is characterized also by pronounced bio-seasonality with dry and hot summers, moist and cool winters, and large year to year variability of total rainfall. The existing datasets on climatic variables differ across the countries of the region, making their comparison at least a difficult task. The most critical issue though for merging and collating the data is the variation in the methodological approaches used so far for the development of maps at the national level.

Soil types, distribution and morphology - availability of databases and maps at regional level

The following information refers only to countries of the region that provided information on the topic. Maps of forest ecosystems exist in Croatia (soil types, forest communities and topography together with classification of forest ecosystems), while additional geological maps are also available. Serbia, as a non-EU member country does not have to implement the 'Infrastructure for SPatial InfoRmation in Europe initiative' Directive, but a digital soil map is currently under construction. In Bulgaria maps of the soil in the ratio of 1:400'000 exist already, but they are often not detailed enough to reach the stand scale. A map of soils has been constructed for Romania by the ICPA Bucuresti and is currently available. The map is in GIS format and has a reference scale of 1:200'000. On the other hand, different types of soil maps including the territory of Romania are also available on the EU site (eusoils.jrc.ec.europa.eu). In Greece soil and topography regional/national maps can be obtained from the European Soil Data Base (ESDB) on a 1:1'000'000 scale and in raster vector data format, as well as from the Institute of Geology and Mineral Exploitation, the Aristotle University of Thessaloniki and the Institute of Mediterranean Forest Ecosystems and Forest Products Technology, located in Athens. Apart from the already mentioned maps there are also topographic maps at a different scale. There are also detailed soil, geological substrate, topographical, and climate/rainfall, maps for Bosnia and Herzegovina. All the above mentioned maps were created in view of defining areas of forests and forest grounds (Stefanovic et al. 1983).

Climate change scenarios for the region

In Slovenia, forecasts for tree species distribution and potential forest-site conditions are generated from models and scenarios for climate change. The forecasts are based on currently observed spatial relationships between climate and vegetation/species distribution accounting also for some ancillary influences, such as soil and relief (Kutnar & Kobler 2011, Kutnar et al. 2009). In Croatia and Bosnia & Herzegovina, the Meteorological and Hydrological Service is responsible for the monitoring of climate and the construction of climatic maps that are currently available on its website (Vukeli et al. 2010). In Serbia, climate projections have been carried out for two periods (2001-2030 and 2017-2100) and under two SRES scenarios yielding contrasting results. In Bulgaria the climate change prediction and modelling (realistic scenarios for temperature and precipitation) is carried out by the Bulgarian National Institute for Meteorology and Hydrology and results can be available upon request. An indicative scenario for climate change is currently available for the country, while a scenario related to rainfall changes is available from the same source. There are climate change scenarios developed for Romania, as for example those issued by the National Meteorological Administration for the time period up to 2030 (Busuioc et al. 2012) or based on simulations of forest microclimate (Zoran et al. 2008). In Greece digital, online and real time point weather data are available at a weather station level, from the Hellenic National Meteorological Service (http://www.hnms.gr/hnms/english/climatology/), while data on surface wind, rainfall, snowfall, cloudiness, air temperature and atmospheric pressure are available for viewing online at the Hellenic Center for Marine Research/POSEIDON SYSTEM (http://poseidon.hcmr.gr/). Climate change scenarios and models are run by the National Observatory of Athens (NOA) - Institute for Environmental Research and Sustainable Development (IERSD) (http://www.meteo.noa.gr). According to the data of the Ukrainian Research Institute of Hydrometeorology (URIHM - http://

uhmi.org.ua/) the effects of climate change have already been noticed. Forecasts for climate change in Ukraine until 2050 have already been developed.

The last report from the International Panel on Climate Change (IPPC 2013) highlights the Mediterranean as one of the most vulnerable regions in the world to the impacts of global warming. The models issued by IPCC cast different scenarios for the Region, but all of them coincide on a clear trend of certain climatic parameters. In terms of thermal regime, the base scenario from 1980-2000 was used to estimate an increase in average surface temperatures, 2.2 and 5.1 °C for the period 2080-2100. For the same period, the models indicate pronounced rainfall regime changes in the Mediterranean, and estimate that precipitation over lands might vary between -4% and -27%.

Vegetation aspect

Diffusion of forests

South-eastern Europe was one of the main areas in Europe where plant species found shelter in refugia and survived during the last glaciation. Refugia were the source areas for the postglacial colonization of many forest tree species, such as *Quercus* species (Petit et al. 2002) or *Abies alba* (Liepelt et al. 2009). However, the northern areas of the region (e.g. Carpathian region) were not necessarily colonized from source areas originating from its southern part (*Fagus sylvatica*, Magri et al. 2006). Therefore, the current ranges of forest tree species have resulted from different patterns of postglacial migration.

Prevalent forests and forest types

Extensive coniferous and broadleaved forests are growing across the whole region. In Slovenia the 62% of the country is forested, while 70% of the forests are pure *Fagus sylvatica* forests and mixed forests of *Fagus* with *Quercus* species or *Abies alba*. The growing stock, produced from the 71 forest tree species growing naturally in the country, is around 332 m^3/ha, while the species contributing more are *Fagus sylvatica* (32%), *Picea abies* (L.) Karst (32%), *Abies alba* Mill. (8%) and *Quercus* spp. (7%). Fifteen species meet the limits of their northern distribution and 4 species the limits of their southern distribution in the country and thus, marginal/peripheral populations are being identified. In Croatia forests cover the 47% of the total area of the country. Most of the forests (78%) are state owned. Forests are classified as commercial, protected and special purpose ones. Out of the 398 million m^3 growing stock 76% comes from state forests, 20% from privately owned ones and 4% is managed from several legal entities. In Bosnia & Herzegovina forests and forest land occupy 53% of the total area, percent that is among the highest in Europe. Out of the above area the high value forests occupy 1'652'400 ha, while coppice forests and all other types of shrub communities occupy 1'252'200 ha (Lojo & Balić 2011). Forests are mainly naturally regenerated and thus exhibit large diversity, while almost 50% of state-managed forests in the country are FSC (Forest Stewardship Council) certified. Among the four identified ecological/vegetation zones (Pannonian, Inner Dinarides, Trans Iliric-Mesiac, Sub-mediterranean, Mediterranean), the Mediterranean one harbours most of the marginal/peripheral tree populations. Serbia's forested area corresponds to 29.1% of the total area, while it has increased by 5.2% since 1979. Out of these forests, 64.7% are coppice forests, 27.5% natural high ones and 7.8% artificially established stands, including plantations. Forty-nine species grow in the Serbian forests, with the broadleaved species being almost fourfold more than the coniferous ones. The dominant species is *Fagus sylvatica* contributing with 40.5% to the total wood volume produced in the country, while *Picea abies*, being the most significant conifer, contributes by 5.2%. Forests in Greece cover 25.4% of the total area and they harbour 400 tree species, out of which 42% are evergreen broadleaved, 20% noble broadleaved and 38% conifers. Forest ownership is by 65.5% public, 22.51% private, and the rest are owned by other enterprises. High forests cover 34.7% of the forested area, coppice forests the 48% and the mixed high coniferous with coppice broadleaved ones the 17.3%. *Quercus* spp. forests correspond to 29.8% of the forested area, while those of *Abies* spp. to 13.1%, *Pinus halepensis/brutia* to 18.9%, *Fagus* spp. to 8.9% and *Pinus nigra* to 5.5%. Rear edge peripheral as well as ecologically marginal populations can be recognized for all the species naturally growing in the country. Several species meet their natural distribution limits in Greece, such as *Pinus halepensis*, *Pinus brutia*, *Pinus sylvestris*, *Fagus sylvatica*, *Abies alba*, *Picea abies*, *Castanea sativa* and *Prunus avium*. The forests of Bulgaria comprising 33% of the total land area are by 97.3% state-owned. Coniferous and deciduous species occupy 33.1% and 66.9% of the forested area, respectively (Grouev 1984). The most abundant species are *Quercus* spp. and *Fagus* spp. among the broadleaved ones (35.2% and 16.4% of the forested area, respectively), and *Pinus sylvestris* and *P. nigra* among the conifers (14.8% and 7.6% of the forested area, respectively). The most economically important species are *Fagus sylvatica*, *Quercus* spp., *Populus* spp., *Fraxinus* spp., *Pinus sylvestris*, *Pinus nigra*, *Picea excelsa*, *Abies alba*, and *Pinus peuce* (Grouev, 1984). According to the most recent national inventory, in Romania forests cover 29.6% (6.9 mil. ha) of the total land area. Forests are unevenly distributed across the country, being concentrated mainly in the Carpathian Mountains and the adjacent hilly regions (more than 90%). The main forest tree species are *Fagus sylvatica* (31%), followed by *Picea abies* (22%), *Quercus* spp. (16%) and *Abies alba* (4%). Several forest tree species meet the north-eastern margin of their natural distribution range in Romania (e.g. *Quercus cerris*, *Q. pubescens*, *Q. frainetto*) and for these peripheral populations can be identified. Ukraine's forest coverage is up to 15.9% of the land area, while varies greatly from region to region, ranging from 34% in the Carpathian region to 4% on average in the steppe. The most forested areas are concentrated in the Carpathian Mountains (mainly covered by *Picea abies*, *Fagus sylvatica* and *Abies alba*) and the Northern territories (mainly *Pinus sylvestris* plantations), and currently 26.8% of the state-managed forests are FSC certified. Four ecological/vegetation zones can be recognized: Carpathians, Polissya, forest steppe and steppe regions. Currently 20 economically important native wood species are used, while marginal populations of tree species lie mainly in the transition area between the Carpathians and the forest steppe region.

Species that are more common and/or representative

Based on the number of plant species growing in the area, South-eastern Europe is almost as species rich as the sub-tropical areas. However, the interesting element of its flora and fauna are the endemic and sub-endemic species, which are closely tied to specific plant communities and ecosystems. A large number of these species are of great importance, as their closer related species can only be found in the farthest reaches of Southeast Asia and North America. *Pinus peuce* Griseb. is a five needle pine growing in the region with its closest related species being *P. wallichiana*, growing in western Himalaya, while *Pinus omorica* is the only existing European representative of the section Omorika, whose other extant species are found in eastern Asia and North America (Turrill 1958). The above fact points to their origins in the oldest geological epochs and to their connection to the climate itself (Kutnar & Kobler 2011, Kutnar et al. 2009).

Major threats to forests

As in other parts of the world, major threats to forests of Southeastern Europe are natural disturbances (e.g. wild fires), fragmentation due to urbanization, overharvesting for fuel and industrial wood, poor management and overgrazing in the mountainous areas.

Expected modifications due to climatic changes

An additional overarching threat across the whole region is the change of the climate itself; causing defoliation, lack of flowering synchronization (Alizoti et al. 2010) and a dieback of oak forests (e.g. in Serbia). Altitudinal migration of species above the previous tree line has been reported in some areas (e.g. Greece).

Forest species at their edge of distribution range

Species

Marginal/peripheral (MaP) populations can be identified for most of the forest tree species naturally distributed in the region. Nearly all countries have identified MaPs for species of the Fagaceae family (i.e. oaks, beech and sweet chestnut), as well as for coniferous ones (mostly pines, *Picea abies* and *Abies alba*). Rare tree species such as *Celtis turnefortii* (Bosnia and Herzegovina) (Šilić 1983) and *Salix daphnoides* (Slovenia) were also reported.

Kind of marginality occurring in the area

Both types of marginality (geographical and ecological) have been reported for the region. Geographically marginal (peripheral) populations from the leading (northern) and rear (southern) edges of the species distributions can be identified for many forest tree species (e.g. xerophilous oaks). The discontinuous distribution of mountain ranges across the region results in a wide variation of environmental conditions in which many ecologically marginal populations, at the edge of the species niche, may be found.

Genetic information available on marginality

South-eastern Europe shows a high diversity of tree species and is considered a reservoir of genetic diversity. Nevertheless, population genetic studies are scarce and restricted to a few species and countries. This is in many cases due to the poor funding opportunities for molecular studies. The need also to improve the capacity of assessing adaptive traits is urgent. In several countries common garden experiments are in the initial phase and time is needed to gain information on adaptive and economic traits, while in those countries were provenance trials and breeding programs have long been estabished, funding is essential to proceed with management of trials, evaluations of the genetic material, and to move forward with advanced generations breeding schemes.

The most common and economically important forest tree species throughout the region were analyzed both by means of genetic markers and in field trials in nearly all the countries. There is also genetic data for tree species with a small, scattered natural distribution (e.g. *Pinus heldreichii*). In several cases, particularly in Greece, the occurence of genetic differences among central and marginal/peripheral populations was investigated with genetic markers (e.g. Ganopoulos et al. 2011), as well as in networks of experimental trials for adaptive traits (e.g. Alizoti 2000). Marginal oak populations of *Quercus robur* (ssp. *pedunculiflora*) were also analyzed by means of genetic markers in Romania (Curtu et al. 2011).

Most important marginal populations

FP1202 experts have identified important MaP populations in several forest tree species occurring in the region. However, detailed information about MaP populations is restricted to few cases (Table 1).

Forest ecosystems and protected areas

Measures of environmental protection

Conservation of forest genetic resources, including MaP populations, is a component of sustainable forest management in many countries of the region. For instance, there is an action plan for conservation of forest genetics resources in Croatia. The National Register of Forest Genetic Resources in Romania was recently approved by the Ministry of Environment, while a provision in the law for the conservation of genetic resources and biodiversity holds for Greece. Both *in situ* and *ex situ* conservation methods are used across the region, and networks of *in situ* conservation units have been established for the most economically and ecologically important tree species in the region. Many conservation units were included in databases existing at a panEuropean level (e.g. EUFGIS), as they fulfilled the minimum requirements of dynamic genetic conservation units (Koskela et al. 2013). MaP populations, growing in extreme site conditions (e.g. close to the xeric limit), are partly included in *in situ* conservation networks of forest tree species. Large areas with MaP populations are conserved through their inclusion in different types of protected areas (national and nature parks, biosphere reserves, Natura 2000 sites, etc.). Every country in the region has designated seed stands in which plus trees have been selected. Usually there are detailed records of seed stands per species and regions of provenance. Seed storage of the most common forest tree species is used by nearly every country. The *ex situ* methods may usually be used for tree species which are interesting for breeding purposes, but *ex situ* trials/banks have also been established for a number of other species not currently genetically improved. There are breeding populations, such as provenance and progeny trials, that can be valuable for conservation purposes, while conservation seed orchards need to be established for certain marginal species/populations at risk. Clonal and seedling seed orchards have been established for both coniferous and broadleaved tree species. Individual genotypes for some species are also protected in botanical gardens and arboreta across the region.

Existing measures for protection/exploitation/valorization of MaPs

Survey and description of forest genetic resources was partially covered in the course of preparatory actions for EUFORGEN activities (e.g. Greece) and in the framework of the EUFGIS project. There are national registers of forest genetic resources and

Table 1 - Overview of important marginal/peripheral populations identified by the FP1202 experts in Southeastern Europe.

Species	**Country**									**Total**
	BIH	**BG**	**CRO**	**GR**	**MNE**	**SRB**	**SLO**	**ROU**	**UKR**	
Abies alba	4	1	3	1	3	1			11	24
Castanea sativa			2	5			1			8
Fagus sylvatica	5	2	3			2	1	5		18
Fraxinus angustifolia							1			1
Fraxinus excelsior								4		4
Picea abies	5			1	4	1	3	5		19
Pinus brutia				2						2
Pinus cembra							1	2		3
Pinus halepensis				1						1
Pinus heldreichii					1					1
Pinus mugo									3	3
Pinus nigra			3	3	1		1	1		9
Pinus peuce					1					1
Pinus pinea			1	1						2
Pinus sylvestris		1			1				3	5
Prunus avium								1		1
Quercus ilex							1			1
Quercus petraea						2				2
Quercus robur	24		3	1		1		10		39
Sorbus torminalis							2			2
Total	**38**	**4**	**15**	**15**	**11**	**7**	**11**	**28**	**17**	**146**

national lists of basic material (e.g. Romania, Slovenia) with detailed description of every conservation unit/seed stand, including several MaP populations. Small occurrences of vulnerable, endemic and protected species are described (e.g. oak species, *Picea omorika* in Bosnia and Herzegovina). Most of the MaP populations identified by FP1202 experts in the countries of the region are not located in protected area (i.e. nature reserve or national parks, etc.) although in some cases no detailed information was provided (Table 2).

Approximately 27% of the MaP populations are included in Natura 2000 sites, while it seems that one out of four reported populations is included in a genetic conservation unit (Table 2). Many MaP populations (40%) are registered as seed stands and only 14% of them are included in EUFGIS database.

Table 2 - Status of protection and use of important marginal/peripheral populations identified by the FP1202 experts in Southeastern Europe.

Species	Protection			Natura 2000		GCU		Seed stand		EUFGIS	
	reserve	park	no protection/ info	yes	no	yes	no	yes	no	yes	no
Abies alba	2	1	20	3	20	8	15	15	8	1	22
Castanea sativa			8		8		8	1	7		8
Fagus sylvatica		1	18	4	15	2	17	7	12	1	18
Fraxinus angustifolia			1	1		1		1		1	
Fraxinus excelsior			4	4		2	2	2	2	2	2
Picea abies	1	1	17	8	11	6	13	11	8	5	14
Pinus brutia			2	1	1		2		2		2
Pinus cembra			3	2	1	1	2	1	2		3
Pinus halepensis			1		1		1		1		1
Pinus heldreichii			1		1		1		1		1
Pinus mugo	1	1	1		3		3		3		3
Pinus nigra			9	4	5	6	3	3	6	3	6
Pinus peuce			1		1		1		1		1
Pinus pinea			2	2		1	1	1	1		2
Pinus sylvestris		3	2		5		5	1	4		5
Prunus avium			1	1			1	1			1
Quercus ilex	1			1		1		1		1	
Quercus petraea		1	1	0	2	0	2	0	2	0	2
Quercus robur			39	8	31	6	33	7	32	5	34
Sorbus torminalis			2	1	1	2		2		2	
Total	**5**	**8**	**133**	**40**	**106**	**36**	**110**	**54**	**92**	**21**	**125**

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