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Marginal/peripheral populations of forest tree species and their conservation status: report for Baltic region

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Abstract - The Baltic region includes in this report Fennoscandia (Norway, Sweden, Finland, Denmark), the Baltic states (Estonia, Latvia, Lithuania) and Poland. This region is fairly heterogeneous as regards forest history, forest policy, forest economy as well as climate and conditions for forest growth. The climate of the Baltic region is cool, but still drastically modified by the Gulfstream which skirts the western coast of Scandinavia, giving rise to much warmer summers and milder winters than expected based on the latitude. The warming associated with climate change is expected to be particularly pronounced in winter and at high latitudes. In coastal areas precipitation may increase notably. With elevated temperature, the frequency of both spring frost and drought events is predicted to increase in continental parts. The vegetation and forest types are heterogeneous. Fennoscandia has a large proportion of boreal vegetation where coniferous forests dominate and many broadleaves common in Central Europe are rare and scattered. In the Baltic region the most distinct marginal populations are those at the northern fringe of their distribution. The distribution ranges are limited by a combination of different factors such as low winter temperatures, short growing season either for growth or for seed maturation, soil types and human influence. Fragmentation may limit gene flow between stands, and some populations also show slight inbreeding. The countries in the region have protected jointly 4,9 M ha in the main MCPFE categories. The northern part of the region seems to put more weight on nature conservation through no intervention whereas the southern part emphasizes conservation through active management. The countries of the Baltic region have uploaded altogether 1'172 *in situ* genetic conservation units in the European Information System on Forest Genetic Resources (EUFGIS).

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

Geographical characteristics of the Region

Extension, borders and main characteristics

The Baltic region includes in this report Norway, Sweden, Finland, Denmark, Estonia, Latvia, Lithuania and Poland. This region is fairly heterogeneous as regards forest history, forest policy, forest economy as well as climate and conditions for forest growth. Therefore, common descriptors presented here have to be read as generalizations.

The region is surrounded by the North Sea and the Norwegian Sea in the West and the Arctic Ocean in the north. The Baltic Sea forms a major water body inside the region.

The total land area is 153 million hectares and the total forest and other wooded lands amount to 78 million hectares (FOREST EUROPE; UNECE and FAO 2011).

Orography

The north-south running mountain ridge in the border area between Norway and Sweden has a profound effect on the climate and also forms a physical barrier between coastal Norway and most of Sweden. In Poland the Tatra Mountains, the highest mountain range in the Carpathian Mountains, also cause climate diversification.

Human population

The total population size is around 70 million people, and the density of inhabitants per square km ranges from 16 in Norway to 129 in Denmark (FOREST EUROPE; UNECE and FAO 2011).

Ecological aspects

Climatic characteristics of the Region

The climate of the region is cool and obviously influenced by the northern latitude, but still drastically modified by the Gulfstream which skirts the western coast of Scandinavia, giving rise to much warmer summers and milder winters than expected based on the latitude. The difference in mean temperature between January and July is only 10-15°C along the Norwegian coast, but increases to 25-30°C further inland (Moen 1998). The precipitation shows extensive spatial variation in the region. The coastal influence is remarkable in Norway where the precipitation may exceed 3000 mm per year but it is much drier in the shadow of the mountain ridge, about 150 km further east. where the annual precipitation is less than 300 mm (Moen 1998). In

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southern Scandinavia, the Baltic countries and Poland the annual precipitation is around 500-800 mm. The lowest precipitation in the this part of the region is in Finnish and Swedish Lapland, where the rainfall is only 300-500 mm per year (European Environment Agency, https://www.eea.europa.eu/data-and-maps/figures/average-annual-precipitation, accessed 4.8.2017).

Soil characteristics

The repeated glaciations over the past 2 million years have drastically shaped the topography and provided the landscape with sediments from glaciers and rivers, which are very important for tree growth. A large part of the forested area in Fennoscandia is covered by rather acidic bedrock and shallow soils, which explains the predominance of *Picea abies*, *Pinus sylvestris* and birch (*Betula* spp.) forests. In the southern and eastern part of the Baltic area, however, flat lowland areas prevail and the soil conditions are more favorable because of the abundant glacial sediments, fertile bedrocks and relatively warmer climate. As a consequence the diversity of tree species is richer.

Possible future modifications due to climatic change

The warming associated with climate change is expected to be particularly pronounced in winter and at high latitudes. Because of the climatic warming the vegetation zones of southern Scandinavia can potentially move 272-645 km northwards by 2100 (Hickler et al. 2012). Due to the warming of the last decades, the budburst of Norway spruce has consistently advanced (Schleip et al. 2008, Bronson et al. 2009), increasing the risk of late frost damage (Langvall 2011, Jansson et al. 2013). Concurrent with further warming of 2-3°C, certain areas might experience a decrease in precipitation of 5-15 % (Iversen et al. 2005). With elevated temperature and reduced precipitation, the frequency of both spring frost and drought events is predicted to increase (Schlyter et al. 2006).

Vegetation aspects

Diffusion of forests and kinds of forests prevalent

The share of forests is the highest in Finland (76%) and the lowest in Denmark (15%). The vegetation and forest types are heterogeneous. Fennoscandia has a large proportion of boreal vegetation where coniferous forests, mainly *P. abies* and *P. sylvestris*, dominate. The northern distribution limit is fairly continuous for the common species, and it may be difficult to single out specific valuable peripheral populations. *Betula* spp are prevalent broadleaves, and many other broadleaves common in Central Europe are rare and scattered in the north of southern Sweden. Some of the marginal broadleaved populations are remnants from the Atlantic period when climate was milder and Norway spruce had not yet arrived to this part of Europe.

Several so called noble hardwoods grow in Fennoscandia either mixed with other species or forming small stands. E.g., in Finland the important rare broad-leaved species are *Acer platanoides*, *Fraxinus excelsior*, *Tilia cordata*, *Ulmus glabra*, *Ulmus laevis* and *Quercus robur*. With the exception of *U. laevis* all these species are more prevalent in the remaining parts of the Baltic region. Typically the gene flow between stands of the rare broadleaves is limited and in Finland some populations also show slight inbreeding (e.g. Hölkten et al. 2003). More continental species such as *Carpinus betulus* have northern range limits in southern Sweden and Latvia. *Quercus petraea* extends to southern Norway and Sweden, but is almost absent from Finland and the Baltic area. *Taxus baccata* has a distinct coastal distribution in the northern part of the Baltic region (i.e. southern Norway and Sweden, Baltic states), but it has a wide although scattered distribution in continental parts of Central Europe. All along western Norway the climate is very oceanic and, along the coast, many of the rare broadleaves extend their distribution further to the north than anywhere else. From a forestry perspective the most significant species in Poland are *P. sylvestris*, *P. abies*, *Abies alba*, *Larix Europeae*, *Fagus sylvatica*, *Q. petraea* and *Q. robur*. Coniferous species dominate in Polish forests, accounting for 70.8% of the total forest area. In addition, Poland hosts species which are rare or absent further north, such as *Sorbus torminalis*, *Tilia platyphyllos*, *U. laevis*, *Acer campestre* and *Pinus cembra*.

Forest species at the edge of the distribution range

In the Baltic region the most distinct marginal populations are those at the northern fringe of their distribution, often being at the leading edge of the species' ranges. The reason that limits the distribution further north is a combination of different factors such as low winter temperatures, short growing season either for growth or for seed maturation, soil types and human influence. Typically, the gene flow between stands is limited and some populations also show slight inbreeding (cf. Höltken et al. 2003).

Due to the favourable climate provided by the Gulfstream, a range of species have absolute northern distribution limits along the Norwegian coast,

including *Taxus baccata*, *F. sylvatica*, *Fraxinus excelsior*, *Tilia cordata*, *Corylus avellana*, *U. glabra*, *Q. petraea*, *Q. robur* and *Ilex aquifolium*. However, the coarse topography with fjords and mountains causes fragmentation and partial isolation of populations. The economically most important species in Finland are *P. sylvestris*, *P. abies* and *Betula pendula*. These species are widespread with continuous distribution and extensive gene-flow by both pollen and seed. Furthermore, they show pattern of clinal variation in adaptive traits (Karhu et al. 1996; Myking and Heide 1995). The northern distribution limit of these species is in northern Fennoscandia.

Genetic information on marginality exists for, e.g., *T. baccata* (Myking et al. 2009), *F. sylvatica* (Myking et al. 2011), *F. excelsior* (Höltken et al. 2003; Tollefsrud et al. 2016), *U. glabra* (Myking and Yakovlev 2006; Myking and Skrøppa 2007), *C. avellana* (Persson et al. 2004), *A. platanoides* (Rusanen et al. 2003) and *P. abies* (Tollefsrud et al. 2008). Marginal populations may host less variation and are more differentiated than central populations, due to a long history of genetic drift or inbreeding. Bottlenecks during the postglacial expansion might also have depleted marginal populations (Savolainen and Kuittinen 2000). Such a central-marginal pattern has been shown in several forest trees in the Baltic region, including *C. avellana*, *P. abies and T. baccata* (Persson et al. 2004; Tollefsrud et al. 2008; Myking et al. 2009). In other species, however, neutral marker variation is of similar magnitude in central and marginal areas (Tigerstedt 1994; Karhu et al. 1996; Savolainen 1997; Eckert et al. 2008). There are also species contrasting with this pattern, such as *A. platanoides*, in which the genetic diversity increases when approaching the northern fringe (Rusanen et al. 2003).

Forest ecosystems and protected areas

Measures of environment protection

In order to promote biodiversity conservation, the countries in the region have protected jointly 1,2 M ha in the MCPFE category "no active intervention", 2,2 M ha in the category "minimum intervention and 1,5 M ha in the category "conservation through active management". The northern part of the region seems to put more weight on nature conservation through no intervention whereas the southern part emphasizes conservation through active management (FOREST EUROPE; UNECE and FAO 2011).

According to the IUCN classification on nature conservation, the region includes 144 national parks with a total area of 51'655 km^2. The level of protection of forest resources within these national parks varies depending on country and park category.

Table 1 - Overview of national parks and their size within the Baltic area (https://www.iucn.org/theme/protected-areas/).

Country	Number of national parks	Total area (km^2)
Denmark	3	1 889
Estonia	5	1 927
Finland	39	9 892
Latvia	4	2 065
Lithuania	5	1 554
Norway	36	24 060
Poland	23	3 149
Sweden	29	7 119
Total	144	51 655

The countries of the Baltic region have altogether 1'172 *in situ* genetic conservation units (GCU) according to the European Information System on Forest Genetic Resources (EUFGIS, www.eufgis.org/). Following the minimum requirements for a gene conservation unit in EUFGIS, the management of the units aims to maintain and enhance the long-term evolutionary potential of tree populations. This means that management measures and silvicultural techniques are applied as needed, to favour evolutionary processes within target tree populations. The units should be monitored and regularly visited.

Table 2 - Overview of specific genetic conservation units1 in the Baltic Area.

Country	Number GCU (in situ)	Number of tree species
Denmark	73	23
Estonia	10	3
Finland	45	8
Latvia	34	9
Lithuania	133	8
Norway	23	10
Poland	607	28
Sweden	247	21
Total		1172

1 EUFGIS database, 12/2016 (http://www.eufgis.org/).

Measures for existing protection/exploitation/valorization of MaPs

Poland has an extensive programme for protection of rare species and populations. It concerns both in situ and ex situ gene conservation, using also in vitro regeneration techniques. One key activity has been to protect and restore T. baccata in Poland (Koziol and Loskot 2009). Conservation of common yew is also carried out in other Baltic countries like, e.g., Latvia, where it is conserved in protected areas, together with Carpinus betulus and F. sylvatica. COST FP 1202 collected information on marginal and peripheral populations in each country. The numbers of reported populations for Finland and Poland are presented in Table 3.

Table 3 - Examples of important marginal and peripheral populations in Finland and Poland identified by the FP1202 experts for the Baltic area.

Species	Finland	Poland	Total
Abies alba		29	29
Pinus sylvestris	2		2
Picea abies	2	31	33
Betula pendula	1		1
Fagus sylvatica		46	46
Fraxinus excelsior	1		1
Quercus robur	1		1
Ulmus glabra	1		1
Total	**8**	**106**	**114**

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