Regions of provenance of European beech (*Fagus sylvatica* L.) in Europe

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ABSTRACT

The EC/1999/105 Directive establishes the regulation on the trade of forest reproductive materials among EU countries. The Region of provenance is the basic unit for the commercialization of forest reproductive materials (fruits, seeds, plants or plants tissues) from categories Source-Identified or Selected. It is defined for a species or subspecies, as a territory with uniform ecological conditions in which are located seed sources or stands with analogous phenotypic or genetic characteristics. It is advisable to know different criteria used by different EU countries to delineate the regions of provenance. In the frame of COST E52 (Genetic Resources of *Fagus sylvatica*)a questionnaire with information onregions of provenance of the species has been compiled for the different countries. The information is available in a GIS server hosted in CIFOR-INIA.

Key words: **FALTAN**

INTRODUCTION

The EC/1999/105 Directive on marketing of forest reproductive materialis based on three principles: the existence of genetic diversity, the importance of different characteristics of the basic material in the future performance of the forest reproductive material and, the difficulty toasses such differences at young stages for an effective control. These schemes are in accordance with the OECDscheme, at least in the identified and selected categories (Nanson, 2001).

The genetic diversity among species is easily recognised, but differences among populations of the same species are in some cases neglected even if they are large for many important traits. Langlet (1971) presented an historical overview on the differentiation among populations in forest trees, and this genetic variation can be influenced by different life-history traits of the species under consideration (Hamrick 1992). The genetic differences among individuals are easily recognised in many forest species, and especially in those of commercial interest with different breeding programmes (*Populus*, *Salix*, *Castanea*, *Juglans*, *Pinus*, *Picea*, among others).Some of the patterns of variation are related to some characteristics of the basic material —specially the origin, the diversity and the selection processes to which populations have been submitted— which influence the future performance of the plantations. Two main difficulties are related with the assessment of such characteristics, and the necessity of implementation of an efficient control system at European level. This control system covers the entire production chain, from seeds to plants, in order to avoid fraud in the commercialization process.

The genetic quality of the reproductive material should, therefore, ideally be based on sound knowledge of the genetic basis of the processes of selection andcharacterization of the plant material un-

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der consideration, as well as by evaluation of the material under common garden conditions. This of course is not always feasible.

One of the central concepts for the use of forest reproductive material is the *origin* of the material. The origin determines many important characteristics related to the future performance of the plants (*e.g.,* traits related to adaptation to climate, traits related to adaptation to biotic or non biotic factors, growth, survival), as a result of the evolutionary factors that shape the genetic structure of the populations in forest species. Many studies have demonstrated a high level of differentiation among populations for traits under selection (such as bud set, growth initiation and cessation, frost tolerance, and drought tolerance) (*e.g.,* Van Andel, 1998). However, the characters related to migration, isolation, genetic drift (*i.e.* not under selection); present a variable level of differentiation.

The region of provenance is the practical application of this knowledge to the marketing or forest reproductive material, and is the basisof the marketing for source-identified and selected forest reproductive material. The region of provenance can be considered a *procurement zone* of forest reproductive material, instead of a *deployment zone* (see Van Buijtenen, 1992).

We can recognise five main characteristics of a system of regions of provenance. a) *The region of provenance determines the geographical limits from which reproductive material can be mixed for commercialization.* Both source-identified and selected reproductive material have to be collected in seed sources or stands from one region of provenance. b) *The region of provenance simplify the marketing of forest reproductive material by identifying zones in which seed or fruits have been collected.* For a species as *Fagus sylvatica* thereare a limited number of regions of provenance in Europe, but thousands of seed sources or stands. Therefore, it is easier for the user to recognise regions of provenance instead each of the seed sources or stands. c) *The region of provenance simplifies the seed transfer rules in national forestation programmes*. Usually, seed transfer rules are based on information on a limited number of progeny trialsevaluated in a limited set of ecological conditions. Therefore, it is much easier to define the rules for each region instead of rules for specific seed sources or stands. d) *The region of provenance can be used for planning breeding or conservation activities*. A region, or several regions, can be combined to constitute a breeding zone in a breeding or conservation programme. e) *The practical importance for marketing is different for each region, and therefore they are not used similarly in restoration programmes.* Some regions are subjectto be used in a broad spectrum of ecological situations, whereas some others are restricted to a local use.

Taking into consideration those different aspects, regions of provenance for the main forest tree species in a country (*e.g.* Alía *et al.,* 2009), are the first reference in the selection of the material for improvement and restoration programmes, and a deep knowledge on the ecological, phenotypic or genetic characteristics of the different regions is essential for a correct choice of the material to be used in each case. After identifying the most suitable region of provenance we have to decide on other characteristics of the material as type of basic material and on the category of the forest reproductive material.

Two main methods (agglomerative and divisive) have been followed to establish the regions of provenance in Europe, and they are available for the different European countries.In the **Divisive method** the territory is divided into disjoint ecologically homogeneous regions, taking into account climatic, geographical, and soil traits related to the performance of the species under consideration. This method has been applied in different European countries (see Gordon, 1992; CEMAGREF, 2003; García del Barrio *et al.,* 2001, 2005; Buiteveld *et al.,* 2000). This method has the main advantage of defining the same regions for all the species under consideration, but it does not take into account some possible special characteristics of the species (*e.g.,* patterns of genetic variation, distribution patterns). In

the **Agglomerative method**the stands of a species with similar phenotypic, genetic or ecological characteristics are grouped to form a region of provenance. Therefore, each species has different regions of provenance, but they describe more precisely the pattern on known variation of the species. This method can be used for species with precise information on phenotypic, genetic or ecological variation. Other methods as the Focal Point seed zones (Parker, 1992; Parker *et al.,* 2004; Westfall, 1992; O'Neill and Aitken, 2004) have been defined, but they are non-fixed procurement zones that do not follow the requisites of the EU Directive or they are based on an exhaustive knowledge of the variation pattern of the species. A third possibility is used by some European countries like Ireland and the Netherlands where the whole country is considered as one Region of Provenance and where individual stands or populations are identified as distinguished provenances that should be kept separate throughout the whole process from seed harvest to final commercialisation (Buiteveld *et al.,* 2000).

Although the article 19.2 of theEC/1999/105 Directive describesthat member states have the commitment to draw maps that include the Region of Provenance distribution, and this basic information must be submitted to the Commission and to all other member states, there is a lack of information concerning the compilation of all this information. This step, however, is necessary to improve the use of forest reproductive material in the international context, and also to improve our knowledge on the genetic basis of such delineation. The description is available from the different designated authorities in each country (*e.g.,* CEMAGREF, 2003, for France, Martín *et al.,* 1998; García del Barrio *et al.,* 2001, 2005 for Spain) or a comparison is made for different countries together (Buiteveld *et al.,* 2000).

In this paper we summarise the criteria used in different countries to delineate the regions of provenance of *Fagus sylvatica* in Europe, based on a questionnaire circulated among all the members of the COST E52 Action on Genetic Resources of Beech.

TABLE 1
Information requested to the different countries

Methods
Agglomerative method (for each species separately)
Divisive method
— For each species separately
— For all the species
Criteria
Geographical information
Altitude
Climate
Soil
Neutral markers information
Field test information
Nursery/phytotron test information
Growth
Phenology
Resistance to diseases/pests
Overall adaptation
Comment: Others (detail)
Information
Maps
Comment: Person/centre for contact
GIS information
Descriptive tables with main characteristics
Monographiesavailable

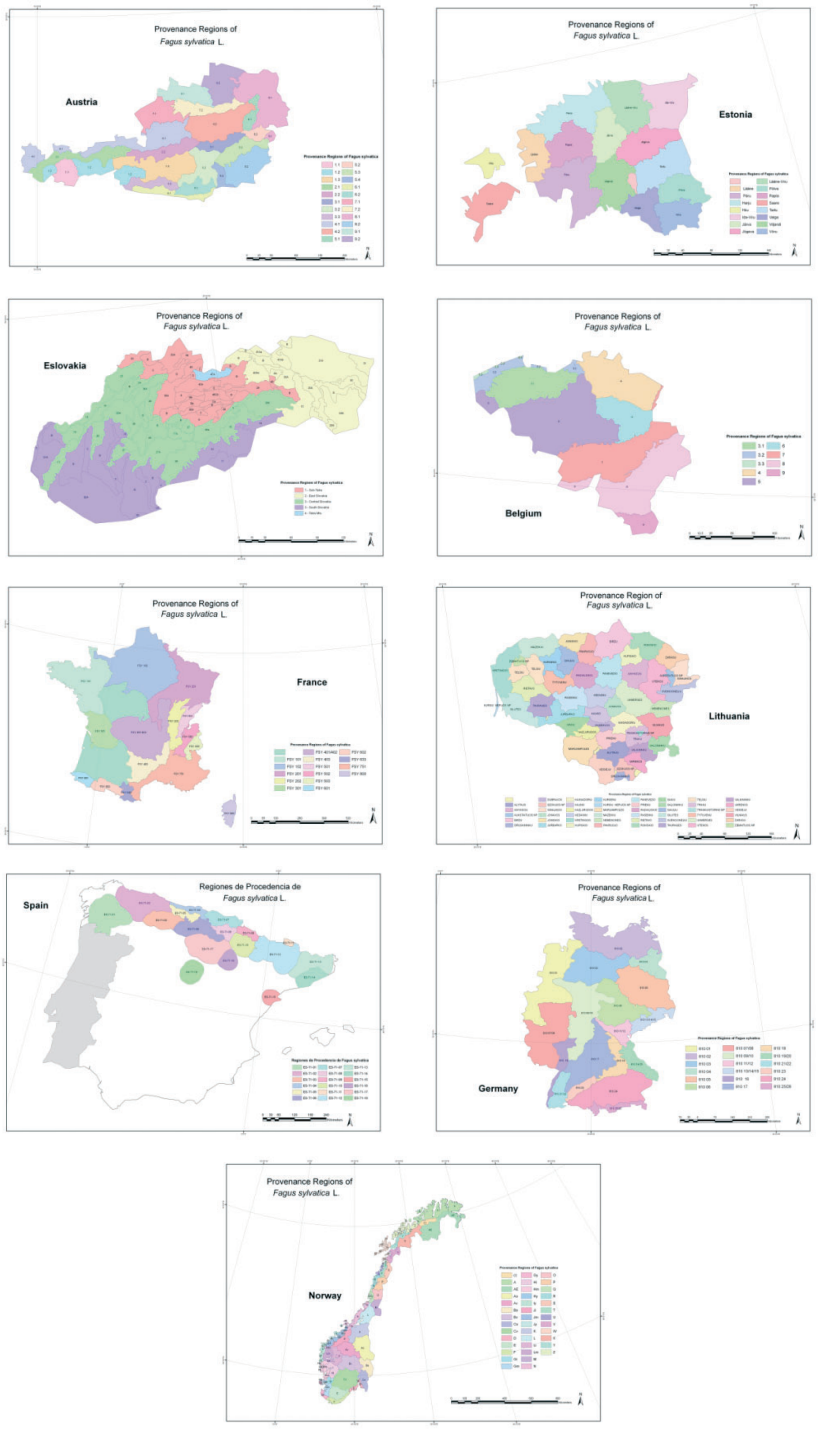

Figure 1. Maps provided for the different European countries.

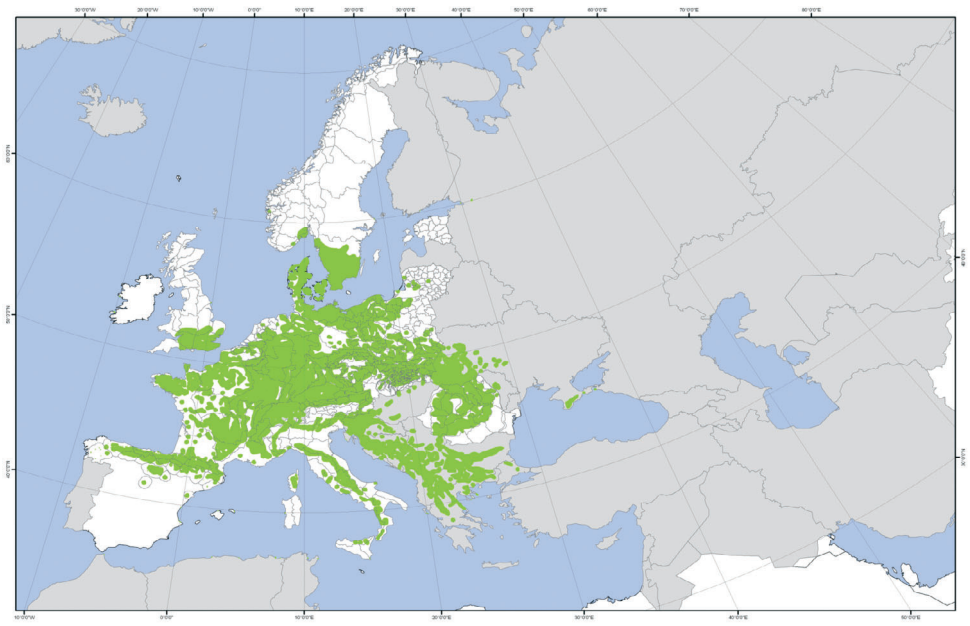

Figure 2. Map of Provenance regions of European Beech (*Fagus sylvatica* L.) in Europe.

TABLE 2
Number of regions of provenance for *Fagus sylvatica* by countries and delimitation methodology applied

	Delimiation method		Number of provenance regions
	Aglomerative	Divisive	
Belgium	×		9
Sweden		×	5
Greece			5
Poland		×	68
France		×	16
Denmark			1
Ireland			1
Rumania		×	46
Eslovakia			5
Netherlands		×	1
Czech Republic			41
Bulgaria			12
Austria		×	22
Slovenia			7
Hungary			6
Croatia			
Germany		×	26
Italy		×	
Serbia			
Spain	×		18
United Kingdow		×	4
Switzerland			14
Estonia			15
Lithuania		×	47
Norway		×	40

TABLE 3
Summary of different criterion and available information for several species relative to delimitation of provenance regions in each European country

Countries	Criterion											Information			
	Geographic information	Elevation	Climate	Soil	Genetic neutral markers information	Field trial information	Greenhouse/ phytotron information	Growth information	Phenology	Pathogen and pest resistance	General aaptation	Maps	GIS information	Descriptive tables with main charac- teristics	Monographs available
Belgium	×	×	×	×	×			×	×	×	×	×	×	×	
Sweden	×											×			
Greece															
Poland	×	×	×	×		×		×	×		×	×	×	×	×
France	×	×	×	×	×	×		×	×		×	×	×	×	×
Denmark															
Ireland															
Rumania	×	×	×	×							×	×	×	×	
Eslovakia															
Nether-lands															
Czech Republic															
Bulgaria															
Austria	×	×	×	×								×		×	
Slovenia															
Hungary															
Croatia															
Germany	×	×	×	×				×	×	×	×	×		×	
Italy	×	×	×	×	×	×	×	×	×		×	×	×	×	×
Serbia															
Spain	×	×	×	×	×	×	×	×			×	×	×	×	×
United Kingdow	×	×	×			×				×	×	×	×	×	×
Switzer-land															
Estonia															
Lithuania	×	×	×	×		×	×	×	×		×	×	×	×	×
Norway	×	×	×								×	×			

METHODS

The Information was provided by members of the Cost Action E52 (Genetic Resources of *Fagus sylvatica*) from different European countries. A questionnaire was circulated including methods, criteria and availability of information (Table 1), in which they identify the methods of delineation, the main criteria used to delineate the regions of provenance and the information available from the different countries.

This information has been summarized from different countries (Fig. 1) and has been compiled in a European map (Fig. 2) using a GIS utilities (Arc Gis 9.3).

RESULTS AND PERSPECTIVES

Table 2 summarises the methods applied in the delineation of regions of provenance, and the number or regions for European Beech in each country.

Usually a divisive method has been applied to the delineation of regions of provenance in Europe, giving a quite heterogeneous number of regions for the different countries. This depends of course to some extent to the size of the country and to the variation of ecological and geographical conditions in a country.

The criteria used to establish such division are also quite heterogeneous depending on the country and therefore the information available (Table 3). Geographical and ecological information is always used, but only in few cases, it would be possible to use more precise information on the genetic variation of the species.

The information provided by the evaluation of the international provenance tests (Von Wühlisch, *et al.,* 1995 and other results of the COST E52 action) as well as the results obtained using molecular markers (*e.g.* isozymes, CpSSR) would allow the identification of areas where the actual regions could be highly heterogeneous, and therefore their limits must be reconsidered. However, in most of the cases, given the reduced size of the regions, this information could presumably be used to precise the deployment zones of the material produced in each region of provenance, and especially under climatic change scenarios. This has to be further investigated.

It is also worthy to notice that this compiled information (Fig. 2) is of high importance for the conservation of genetic resources of beech, as it provides useful information onunits of ecologically significance for breeding and conservation.

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