CURRENT AND FUTURE STATUS OF SCOTS PINE (*Pinus sylvestris* L.) FORESTS IN EUROPE

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SUMMARY

There was a major expansion in the area of Scots pine forests in Europe during the twentieth century so that this forest type now exceeds 20 per cent of the productive forest area of the EU. Although the main aim of this expansion was to increase timber production, a wider range of management objectives has become more important during recent decades. These changes may affect the future status and development of Scots pine forests. To analyse the potential impacts, a questionnaire was distributed among the participants in this Concerted Action (CA) to compare the present and future situation in Scots pine forests in different European countries.

The results showed the role of Scots pine in different countries of Europe varies from a pioneer plantation species on degraded agricultural land to a dominant component of a native forest ecosystem. There is a general expectation of a move away from simple management systems towards a more complex silviculture based upon greater use of natural regeneration and with a greater diversity of tree species and ages. This move is likely to be more pronounced in central and western Europe where the economic returns from current management are low. These changes are likely to have benefits for biodiversity, particularly where they are accompanied by increased provision of deadwood. Until recently, studies of genetic diversity in Scots pine have laid greatest emphasis on improving growth traits to enhance timber production. There are successful breeding programmes in a number of member states which are reporting potential gains of 10-20 per cent in volume. However, increasing interest is now being given to the conservation of isolated populations which are found under extreme environmental conditions for the species and which have potential importance in the maintenance of genetic diversity. A number of these populations are under threat and action is required to safeguard their future.

Despite these changes, Scots pine will continue to be a most important forest species in Europe for the foreseeable future. The anticipated changes in management practices are in line with the recommendations of resolutions on sustainable forest management passed at the 1998 Lisbon Ministerial Conference on Protection of Forests in Europe. The challenge is to develop management systems that are economically viable, but provide the range of non-market benefits required by the needs of sustainable forest management.

KEY WORDS: Scots pine
Silviculture
Genetic Conservation
Future trends

INTRODUCTION

Scots pine (*Pinus sylvestris* L.) is the most widely distributed conifer in the world, and the range spreads over a distance of 14,000 km, from 8ºW in Spain to 141ºE in Russia and from latitude 70ºN to 37ºN (Boratynski, 1991). Natural forests or plantations of this species are found in all member states of the EU, and it is of considerable importance as a timber producing species, particularly in the Nordic countries.

In the 1990s, a shift has occurred in the objectives of European forest management from an emphasis on timber production towards multiple objectives including the maintenance and increase of biodiversity, conservation of genetic resources, provision of social benefits such as recreation, prevention of global warming and CO_2 fixation. Sustainable forest management is recognised as the way to satisfy these different demands, and is believed to be the way forward for all European forest management, including Scots pine forests. These changes are documented in the resolutions passed at the Ministerial Conferences on the Protection of Forests in Europe (MCPFE) in Strasbourg in 1990, Helsinki in 1993, and Lisbon in 1998.

While much information has been published on the productivity (e.g. Assmann, 1970), genetics (Giertrych and Matyas, 1991), silviculture, and conservation status of Scots pine forests, sustainable management of these forests depends upon the integration of findings from a range of disciplines. This should allow the identification of key issues that have to be confronted if multi-purpose management is to be implemented. This paper attempts such a synthesis based upon the knowledge shared by participants in the EU Concerted Action (CA) «Silviculture and Biodiversity of Scots pine forests in Europe». The results are evaluated in the light of relevant resolutions passed at the third MCPFE in Lisbon.

MATERIAL AND METHODS

Participants in the CA came from the following member states: Austria, Belgium, Finland, France, Germany, Ireland, Netherlands, Spain, Sweden, and the United Kingdom. A Hungarian scientist also participated in the deliberations of the CA. The only EU member states not involved were: Denmark, Greece, Italy, Luxembourg and Portugal, which have only comparatively small areas of Scots pine forest (estimated as being less than 100,000 ha. for the 5 countries combined).

A questionnaire (see Appendix 1) was circulated to all participants between March and June 1999 seeking information on the current status of Scots pine forests in their country, their structure and management, and upon aspects of tree breeding and of conservation value. The replies were collated to provide the material presented in the following sections.

RESULTS

Area, age-class distribution, and future status of Scots pine forests

The extent of Scots pine forests exceeds 28 million hectares, representing at least 20% of the commercial forest area of the EU (Table 1). This is about 12 per cent of the world distribution of the species. Nearly 80 percent of this area is to be found in two Scandinavian states (Sweden and Finland). Germany, France and Spain also have substantial areas of Scots pine forests in excess of 1 million hectares. The larger areas of forest tend to be found in those countries where Scots pine is a native species. Not all states were able to provide information on the age-class distribution of these forests, but there appears to be only a small representation of older age classes (>100 years of age). In all states except Belgium there was a general increase in the pinewood area during the twentieth century. This increase had either stabilised or, in some instances, had been reversed in the latter decades of the century. These reductions can be explained by the replacement of Scots pine by another more productive species (e.g. by *Pinus nigra* in Belgium; by *Picea abies* in Finland), or by the conversion of pure pine stands to more complex structures (mixed or broadleaved forests). No major changes are anticipated in the proportion of Scots pine stands in various member states in the present century other than in Belgium and Hungary. However, in nearly all instances, the proportion of mixed stands of Scots pine and a range of other species is expected to increase.

TABLE 1

AREA OF SCOTS PINE FORESTS IN DIFFERENT EU MEMBER STATES, AMOUNT OF MIXED STANDS, AGE-CLASS DISTRIBUTION AND CHANGES EXPECTED IN THE PRESENT CENTURY

Superficie del Pino silvestre en diferentes Estados miembros de la UE, cantidad de masas mixtas, distribución de las clases de edad y cambios esperados durante este siglo

Country	Scots pine stands				Mixed stands		Age class distribution		
	Native stands	Area (‘000 ha)	Change from 1900	Expected in 2100	Area (%)	Expected in 2100	<60	60-100	>100
Austria (AT)	Y	140	>	=	66	=	35	36	29
Belgium (BE)	N	65	<	<	10	>	50	45	5
Finland (FI)	Y	13000	>	=	54	>	60	20	20
France (FR)	Y	1150	>	=	22	>			
Germany (GE)	Y	3007	>	=					
Hungary (HU)	N	148	>>	<	5	>			
Ireland (IR)	N	8	>	=			75	20	5
Netherlands (NE)	N	96	>	=	9	>			
Spain (SP)	Y	1280	>	=	26	>	45	25	30
Sweden (SW)	Y	9300	>	=	50	>			
United Kingdom (UK)	Y	241	>	=	20	>	65	25	10

Note: The sources for these figures are the various national inventories for the respective countries plus additional information provided by the participants.

The main tree species found in mixture with Scots pine are:

AT: *Abies alba, Fagus sylvatica, Larix decidua, Picea abies, Quercus petraea, Q. robur*
BE: *Betula pendula, Quercus robur*
FI: *Betula pendula, B. pubescens, Picea abies, Populus tremula*
FR: *Abies alba, Fagus sylvatica, Larix decidua, Picea abies, Pinus uncinata, Quercus petraea, Q. robur*
GE: *Abies alba, Fagus sylvatica, Picea abies, Quercus petraea, Q. robur*
HU: *Carpinus betulus, Fagus sylvatica, Quercus petraea, Q. cerris*
SP: *Abies alba, Fagus sylvatica, Pinus uncinata, Quercus pyrenaica, Q. pubescens*
SW: *Betula pendula, B. pubescens, Picea abies*
UK: *Betula pendula, Larix spp., Picea sitchensis, Pinus nigra*

Public or private ownership

Public ownership includes forests owned by the state, communities and NGO's whereas private forests are those owned by corporations, farmers, etc. The percentage of Scots pine forests in public ownership varies from country to country (Table 2), with the highest and lowest proportions in Hungary and Austria respectively.

TABLE 2

PERCENTAGE OF SCOTS PINE FORESTS IN PUBLIC AND PRIVATE OWNERSHIP

Porcentaje de Pino silvestre según propiedad pública o privada

Ownership	AT	BE	FI	FR	GE	HU	NE	SP	SW	UK
Public	1	35	29	24		70	30	58	30	40
Private	99	65	71	76		30	70	42	70	60

Management objectives

In public forests throughout Europe a multi-purpose management approach has been adopted with sustainable forest management as a long-term goal. Future management strategies emphasise the creation and maintenance of the recreational and conservation value provided by the forests, with special emphasis on ecological sustainability and increasing biodiversity. However, whilst the relative importance of the economic value of Scots pine forest is decreasing in some countries (BE, NE), in others the maximisation of net present value is of considerable importance. This is to be achieved by high volume production combined with the highest possible output of high quality sawlogs (FI, SW).

Silvicultural systems and rotation age

The most commonly used silvicultural system in Scots pine forests is patch clear felling, but there is increasing importance attached to less regular systems, such as irregular shelterwood, or uniform shelterwood (Table 3). Where reported, thinning regimes were invariably based upon low thinning.

TABLE 3

SILVICULTURAL SYSTEMS USED IN SCOTS PINE FORESTS IN DIFFERENT MEMBER STATES AND, WHERE POSSIBLE, ESTIMATED PERCENTAGE USAGE FOR EACH

Tratamientos selvícolas utilizados en Pino silvestre en diferentes Estados miembros, y, cuando posible, porcentaje estimado de uso para cada uno de ellos [una cruz indica que se utiliza el tratamiento. Una marca, indica que se emplea dicho tratamiento en menos del 1 % de la superficie. La terminología de los tratamientos sigue a Matthews (1989)]

Silvicultural system	AT	BE	FI	FR	GE	HU	NE	SP	SW	UK
Clear felling	x	100	50	x	x	100	100	5	50	90
Seed Tree			49	x	x	√			50	5
Uniform shelterwood	x		√	x	x			60	√	3
Strip shelterwood			√		x					√
Group shelterwood		(1)		x				10		√
Irregular shelterwood		(1)		x	x			35		√
Group selection			√		x					√
Single stem selection										

Notes: 1. Previously almost 100% clear cutting was carried out in BE although this system has almost completely been abandoned in the last decade. Systems close to group shelterwood and irregular shelterwood are now used, with clear felling followed by planting being rare.
A cross indicates that a given system is used, but there is no estimate of the percentage. A tick indicates that less than 1 per cent of the area is managed with the particular system. System terminology follows Matthews (1989).

The shortest rotation age reported is 40 years (Hungary) and the longest 140 years (Finland, Sweden) with most values being close to 100 years. There was a general trend in all replies for the rotation ages to be maintained or increased (Table 4) to obtain more mature stands to increase biodiversity, and in some cases trees were being reserved for two rotations or longer.

TABLE 4

NORMAL ROTATION AGES. POORER SITES ARE THOSE IN MORE NORTHERN LATITUDES OR AT HIGHER ELEVATION

Turnos empleados. Los sitios más pobres son aquellos a mayores latitudes o a altitudes más elevadas

	AT	BE	FI	FR	GE	HU	NE	SP	SW	UK
Rotation age	100	50-70			80		60-80	120		75-100
Poorer quality sites			100-140	120		40-50		>120	100-140	
Better quality sites			70-100	80-90		80-100		100-120	70-100	
Expected change by 2100	=	70-120	=	=	>	=	>	=	=	>

Percentage of planting compared with natural regeneration

During the latter half of the twentieth century, technical advances in plant production, and improved efficiency in the management of reforestation sites, resulted in a large increase in the use of artificial regeneration. However, with the exception of Hungary, the Netherlands, and the United Kingdom, natural regeneration is still the main method used to restock Scots pine stands. There is relatively little use of direct seeding outside the Nordic countries. The proportion of natural regeneration is expected to increase (Table 5), partially reflecting the greater use of systems other than clearfelling.

TABLE 5

ESTIMATED IMPORTANCE OF NATURAL VS. ARTIFICIAL REGENERATION IN SCOTS PINE FORESTS

Importancia estimada de la regeneración natural vs artificial en bosques de Pino silvestre

	AT	BE	FI	FR	GE	HU	NE	SP	SW	UK
Planting (%)		0	27	10		100	++	20	25	70
Direct seeding (%)		–	24					5	25	
Natural regeneration (%)		100	49	90				75	50	30
Expected change in amount of planting to 2100	<	=	=	<		=	<	=	=	<

Timber production, and main uses

The amount of Scots pine timber production varies between countries (Table 6), broadly in accordance with the size of the resource. More than 80% of all Scots pine timber production is concentrated in the Nordic countries (FI, SW) with Germany and Spain

TABLE 6

SCOTS PINE TIMBER PRODUCTION IN DIFFERENT EUROPEAN COUNTRIES AND MAIN USES

Producción de madera de Pino silvestre en diferentes países europeos, y usos principales

Country	Annual cut ('000 m^3 yr^{-1})	Volume Increment ('000 m^3 yr^{-1})	Main uses
AT	156		Sawtimber, fibrewood, firewood
BE	101	325	Fibrewood
FI	23,000	33,500	Sawmilling, 11.5 mill m^3 yr^{-1}, pulp and paper industry 11.5 mill m^3 yr^{-1}
FR	147	5,134	Construction, furniture, and high quality veneer products
GE	4,800		Construction, furniture, fibrewood
HU	200		Construction, lumber, fibrewood
NE	130		Fibrewood
SP	1,000	3,692	Furniture, construction, and veneer
SW	16-20,000	35,000	Sawmilling, pulp and paper industry
UK	190		Saw timber, panel boards, chipboard, firewood

being other important producers. In southern countries (SP, FR) the mean production by hectare is quite low, but the timber of Scots pine is very much appreciated for its colour and texture, and is used as veneer in high quality products. For those countries where annual volume increment figures were available, there was a general tendency for the annual cut to be less than the potential.

Management costs, production, and financial returns

As a supplementary measure, participants were asked to provide typical costs and revenues incurred over a rotation in Scots pine forests in their country. More than one example was permitted if there was appreciable regional variation within a country. Costs included cultivation, planting, post plant protection, beating-up, weeding, and fertilisation. Revenues were derived from the net return on volumes sold over a normal rotation either as thinnings or in the final felling. Costs and revenues were based either upon personal experience or were derived from standard tables. National currencies were converted to Euros using exchange rates of June 1999. The balance between costs and revenues was calculated as a net return with and without a 3 percent test discount rate (Table 7).

The results show a trend for Scots pine forests to be more profitable in Sweden, Finland and Spain than in other countries. The highest net returns are found in Spain which appears to reflect a combination of higher prices for large dimension timber and greater productivity. The lowest net returns are on the poorer site in Austria, and in the Netherlands, where high establishment costs are the main cause of this result. Indeed, when using a 3 percent discount rate, there is a negative return on capital in all countries except for Finland, Spain and parts of Sweden. To some extent this reflects the regeneration method assumed, since planting costs appreciably more than natural regeneration. Thus the British example would have a positive outturn if natural regeneration was used.

TABLE 7

NET RETURNS (IN EUR HA^{-1}) AND CUMULATIVE VOLUME PRODUCTION FROM A TYPICAL SCOTS PINE STAND IN A RANGE OF EUROPEAN COUNTRIES

Retornos netos (en Euro ha^{-1}) y producción acumulada en volumen de un rodal típico de Pino silvestre en diferentes países europeos

Country	Net Return (without discount)	Net Return (with 3% discount)	Cumulative volume production (m^3 ha^{-1})
AT (High productivity)	5,768	–3,844	590
AT (Low productivity)	–2,271	–4,219	336
BE (State forest of Ravels)	1.206	–4,153	515
BE (State forest Pijnven)	3,808	–1,303	480
FI (North)	8,271	145	320
FI (South)	12,264	1,055	537
FR (Orléans Forest)	23,816	–630	810
FR (Haguenau Forest)	7,740	–1,893	490
GE	1,304	–4,572	610
NE	–1,886	–2,625	287
SP	50,916	946	820
SW (North)	7,080	–151	381
SW (Central)	11,896	280	448
SW (South)	15,765	976	609
UK	10,578	–64	524

Sources for yield and other data where these are not based upon local experience:

AT - Federal Ministry for Agriculture and Forestry (1996); Marschall (1975); Sterba et al. (1986).

FI - Finnish Statistical Yearbook of Forestry (1997); Riikila and Meilikainen (1998); Vuokila and Vailaho (1980).

FR - Anon. (1994); Anon. (1996).

NL - Wieman and Hekhuis (1996).

SP - Rojo and Montero (1996).

UK - Edwards and Christie (1981).

Grants or other financial support mechanisms specifically designated for the management of Scots pine forests

Financial subsidies for management of Scots pine forests are generally similar to those for other conifer stands, although the amounts are lower for afforestation with Scots pine than with (most) broadleaves. In Great Britain, a higher rate of subsidy is awarded for management of native pinewoods in Scotland because of their high conservation value (see Mason, this volume). In France, there is a special regional grant to improve the productivity of Scots pine forests (e.g. in the Languedoc-Roussillon region grants are awarded for commercial thinning).

MAIN THREATS TO SCOTS PINE FORESTS

Natural Disturbances

The prevailing natural disturbance agent varies greatly among countries, from pests to snow break, wind blow or forest fires (Table 8). Usually the return period is between 10 and 100 years depending upon the disturbance agent. In the case of fire, this is equivalent to a moderate severity fire regime (Agee, 1998). The frequency and intensity of such disturbances can affect the structure of Scots pine forests over time i.e. whether irregular stands develop after frequent fires or even-aged stands after severe fires. Such disturbance can be considered as a dynamic process for influencing the structure of Scots pine forests over space and time. For example, in Finland, almost all Scots pine forests would eventually develop into Norway spruce forests without stand replacing disturbance by fire or harvesting, although wind and insects play a subsidiary role. In central Europe, disturbances tend to be on a smaller scale and are generally followed by development towards a mixed broadleaved/Scots pine stand. The eventual balance between the species present in these mixtures depends upon the scale and intensity of the disturbance (i.e. larger gaps favour Scots pine), but can also be influenced by pressure from grazing animals.

TABLE 8

MAIN NATURAL DISTURBANCES AFFECTING SCOTS PINE FOREST STRUCTURE, AND THE ESTIMATED RETURN PERIOD OF STAND REPLACING EVENTS IF KNOWN

Principales alteraciones naturales que afectan a los bosques de Pino silvestre, y el período de retorno estimado de reemplazo del rodal, si se conoce (una cruz indica que el agente es importante en un país determinado, pero se desconoce la magnitud del período de retorno)

Natural disturbance	AT	BE	FI	FR (2)	GE	HU	NE	SP	SW	UK
Forest fire	X	25	X	15	X		X	>100	X	100
Wind		20	X				X		X	200-50 (1)
Insects	X		X	(3)					X	
Pathogens	X			10 (3)	X					
Snowbreak	X				X	15-20				>200

Notes:
(1) 1 event in 200 years in south, increasing to 1 in 50 years in north
(2) This compilation predates the major storms of December 26-28 1999 which severely damaged Scots pine stands in north-central France and adjacent European countries.
(3) This includes twisting rust *(Melampsora pinitorqua)* on young plantations, defoliations by sawflies, bark beetles.
A cross indicates that the agent is of importance in a given country, but the magnitude of the return period is uncertain.

Anthropogenic factors

In Scandinavia, no major threats are perceived from human actions to the status of Scots pine forests. Elsewhere a range of biotic and abiotic factors may affect the future status of the species (Table 9). In most of Central Europe the presence of Scots pine was felt to have been affected by anthropogenic influences such as pollution, not to mention conversion of forest land to housing. In Southern Europe, due to the fact that the Scots pine forests are usually found at high altitudes, the direct human pressure was lower but there was a major risk of fire damage.

TABLE 9

MAIN ANTHROPOGENIC THREATS TO SCOTS PINE FORESTS AS PERCEIVED BY THE MEMBERS OF THIS CA. NUMBERS IN BRACKETS REFER TO THE NOTES

Principales amenazas antropógenas de los bosques de Pino silvestre, según los distintos miembros de esta AC. Los números en paréntesis se refieren a las notas

Main threats	AT	BE	FI	FR	GE	HU	NE	SP	SW	UK
Fire		X		X				X		Minor
Diseases	X			X	X	X				
Conversion to agriculture										
Conversion to other forest types		(1)				X				X(2)
Overgrazing (e.g. by cattle, sheep, deer)										X(3)
Conversion to housing		X					X			
Pollution		X			X		X			
None			X						X	

Notes:
(1) Conversion to other forest types is a goal of management.
(2) Southern England, *Pinus nigra*.
(3) Especially in the north of Britain.

The monitoring of forest condition in Europe (Müller-Edzards *et al.,* 1997), shows different situations and causes of decline of Scots pine forest. For example, in Southern Europe, the main cause is drought, while in Central Europe it is pollution.

Aspects of biodiversity

There were few aspects of biodiversity reported that were specific to Scots pine forests. An exception was in Great Britain where the native pinewoods in northern Scotland have flora and fauna of high conservation value (Mason, this volume). These include the endemic bird species Scottish crossbill (*Loxia scotica*), other rare bird species together with a group of vulnerable or endangered invertebrate and bryophyte species. In Sweden, a survey of 1487 threatened plant, animal and fungus species found that about 10 per cent were primarily associated with Scots pine forests (Berg et al., 1994). This compared with around 18 per cent that were linked to Norway spruce forests. In other countries, the impression given was that the importance of the pine forests was as an extensive habitat whose management could be adjusted to provide for rare and/or charismatic species. For example, in Spain, the Scots pine forests of the Sierra Guadarrama to the north of Madrid hold important populations of the endangered black vulture (*Aegolius funereus*).

A number of replies noted changes in management policy that would probably have benefits for general biodiversity. Reported practices include the introduction of broad-leaved species such as oak and birch (BE) into pine stands, and increasing the number of retained old trees, snags, deadwood, and stands under non-intervention management (FI, SW, UK: see Hodge and Peterken, 1998). The desirability of such practices is under debate, at least in Southern European countries where the possible effects on the occurrence of diseases, pests, and forest fires are controversial. The variation in response between the different countries, some of them focusing on protected species and others on the future development of the pinewood ecosystem, may reflect a lack of standardisation between member states in the monitoring of biodiversity in Scots pine forests.

Preservation of genetic diversity in natural Scots pine populations

Scots pine was the first forest species in which different provenance studies were performed (Langlet, 1971), and the first IUFRO provenance test of the species was established in 1907 (Giertych, 1991). The high level of genetic variation in the species stimulated the early start to breeding programmes with Scots pine, and influenced the transfer of material between different European countries. As a result, most European countries now have a mosaic of native stands interspersed with plantations of diverse origins.

The second resolution of the Strasbourg conference in 1990 dealt with the genetic conservation of tree species, pointing out the importance of genetic resources in the sustainable management of European forests. The EUFORGEN network was established after this conference to implement the resolution and was divided into a number of different groups (Turok *et al.,* 1995); Scots pine is included in the Conifer network.

Gene conservation is based on the knowledge of the variability of the species (analysed in previous papers), and the consideration of relevant factors (e.g. isolation, use of forest reproductive material, threats, etc.). Most countries do not have national programmes of forest genetic conservation which cover Scots pine, although research in this general area is being carried out in most of them (AT, FI, FR, GE, HU, SP, SW, UK). Gene conservation, as a tool to maintain long-term genetic diversity, is directed mainly at native stands. The main aims of gene conservation (Eriksson, 1996) can be defined as:

- preserving alleles with frequencies greater than 0.01
- maintaining existing adaptation
- creating favourable conditions for future evolution of the forests

Both tree breeding and genetic conservation programmes directly affect the future of Scots pine forests, and below we analyse briefly the most important questions concerning the preservation of genetic resources in relation to the status of Scots pine forest in Europe.

a. Tree breeding programmes and measures: use of native and non-native sources

Most countries have developed tree breeding programmes with Scots pine due to the economic value of the species (Table 10). The EU rules concerning the commercialisation of forest reproductive material restrict the material to that obtained from selected stands

TABLE 10

TREE-BREEDING PROGRAMMES FOR SCOTS PINE; BREEDING POPULATIONS, STATUS OF FOREST REPRODUCTIVE MATERIAL (FRM) LEGISLATION, IMPROVED MATERIAL IN COMMERCIAL USE; LEVEL OF GENETIC GAIN EXPECTED

Programas de mejor genética de Pino silvestre, poblaciones de mejora, uso de material forestal de reproducción, legislación, uso comercial de material mejorado, nivel de ganancia genética esperada

Country	AT	BE	FI	FR	GE	HU	NE	SP	SW	UK
Breeding/conservation zones		1	11	19				17	17	1
Breeding populations		1	4	2				2		1
FRM in use	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
Selected stands	Y	Y	Y	Y	Y			Y	Y	Y
Genetic gain: volume (%)		–	10	20				–		10-15
Genetic gain: stem form (%)				40				–		1-2

or seed orchards. Potential genetic gains, where known, appear to be of the order of 10-20 percent for volume over unimproved material (e.g. Lee, 1999).

The emphasis upon the use of local seed sources is very much dependent on the country. In Austria and Spain, local sources are mainly used. In France, Belgium, Netherlands and Hungary, non-native sources are used to increase stand productivity. In general, each country has particular requirements for transfer of seed origins between different climatic zones.

b. Importance of isolated populations of Scots pine

In the Scandinavian part of the range of Scots pine, the extensive areas of pine forest mean that fragmentation of the population is not usually a problem. However, discontinuities in the distribution are found at the southern and western extent of the natural range; these areas were refugia during glaciations explaining their high genetic distinctiveness (Spain, Great Britain). As these populations are associated with the extremes in the environmental conditions that the species can tolerate, their importance in the maintenance of genetic diversity is high. The most important populations, and those where studies on population diversity have been made are:

Austria:	Local provenances adapted to high altitudes (>1900 m) in the Central Alps
Finland:	Arctic populations
France:	Massif Central (2 populations are distinguished), Alps (2 populations), Pyrenees (with distinction between Eastern and Central populations).

Spain:	6 populations, including two in the southernmost range of the species (Sierra Nevada).
Sweden:	Arctic populations
United Kingdom:	Northern Scotland (up to 20 populations of critically small size (<100 trees) within athreatened EU priority habitat)

In the rest of the natural range (e.g. Italy, Turkey, Russia) other similar populations exist (see Boratynski, 1991, for a more complete description).

c. Endangered populations

The main factors affecting the existence of endangered populations are their small size (in numbers of surviving trees and in area resulting in in-breeding depression and selfing; Scotland and Spain), environmental stresses (Hungary, Spain by drought), hybridisation with non-native seed sources (France, Haguenau population; Scotland), hybridisation with other species (France, Angles population), lack of regeneration through over-grazing (Spain, Scotland) and human interference (Hungary). In countries of Central and Northern Europe, endangered populations of Scots pine are not normally considered as a concern.

d. Main measures of genetic resource conservation

The main method is usually *in situ* conservation, but *ex situ* measures could be necessary in some populations.

in situ: Nature reserves containing Scots pine exist in most countries, but have to be adapted to the aims of genetic conservation, following the guidelines recently established for conifers (Koski, 1996). The size of the population, the structure, and isolation from non-autochthonous seed sources are all of great importance. At this time there is no agreement between different countries as to the most appropriate methods and different measures have been implemented with varying levels of protection.

In Austria registered gene conservation stands have been established (13 totalling 165.5 ha in Scots pine and oak mixed forest; 3 of 39 ha in Scots pine-birch-*Pinus uncinata*; 6 of 141 ha in Scots pine forests on limestone). In Finland, there are 21 gene reserve forests comprising 4,632 ha. In France there is one national programme limited to the Haguenau population with one forest reserve, and one in situ provenance plantation (13 ha). In Hungary forest reserves have been established. In Sweden, gene reserve forests have been defined. In Great Britain, relict native forests have been monitored and their genetic diversity studied.

ex situ: Provenance trials are the most important tool in the study of the adaptation of the sources to a changing environment (Eriksson, 1996). At present the IUFRO network of provenance trials is the only one covering the whole range of the species with a large number of populations. However, only a limited sampling of marginal populations was carried out in this network. Each country has a range of more limited provenance tests, as a major tool for *ex situ* conservation.

CONCLUSIONS

The structure of the questionnaire was intended to elucidate anticipated changes to the present status of Scots pine forests. The replies are based upon the personal judgement of members of the CA and, as a consequence, provide a broad indication of likely trends rather than definitive answers. This is also true where information on aspects of the Scots pine resource in a given member state is either limited or lacking (e.g. on aspects of forest biodiversity).

The replies highlight the substantial increase in the amount of Scots pine forests since 1900 so that these now comprise one of the major forest types within the EU. However, the pine forests fulfil very different roles in the various European countries, ranging from a pioneer community established on abandoned agricultural land in parts of western and central Europe to a natural forest in parts of Scandinavia and in the mountains of north-central Spain.

Given this variation, it is unrealistic to expect a universal theme to emerge from the results of this questionnaire. However, certain trends are apparent. There is a general move away from regular forest structures managed with simple silvicultural systems based upon clearfelling and replanting. There is likely to be greater use of natural regeneration, primarily based upon seed tree or shelterwood silvicultural systems. Greater tree species diversity can be anticipated as a result. This will be of particular importance in western and central Europe where many sites, although degraded by agricultural practices such as litter removal, are inherently relatively fertile and can support a range of broadleaved and conifer species.

An important difference is between those countries where Scots pine forests are profitable (FI, SP, SW) and the remainder where the net returns are negative, when calculated using a 3 per cent interest rate. In some countries in the latter category (e.g. UK) there may be a possibility of improving returns through more cost-effective management. Possible strategies include reducing establishment costs by greater use of natural regeneration, using selected genotypes to increase productivity, improving harvesting efficiency, and using thinning from above to increase the mean tree size in early thinnings. However, in most countries this possibility seems to be limited, so that an increasing trend of transforming regular Scots pine stands into more structurally diverse and species rich forests can be anticipated.

The replies suggested that, with some exceptions (e.g. the native pinewoods of north Scotland), the importance of Scots pine forests for biodiversity is a consequence of this being a major forest type within the EU rather than in particular species associated with these forests. The move away from simple management systems and stand structures outlined above can be anticipated to have beneficial effects upon forest biodiversity, particularly if this is combined with greater maintenance and enhancement of the deadwood habitat.

The importance of the species for timber production has resulted in tree breeding programmes with Scots pine being carried out in most European countries. As a result, most member states have some knowledge of the preferred seed sources to use in order to increase productivity. It is possible that the greater use of natural regeneration noted above may result in a smaller market for improved material. Until recently, there has been less attention paid to the genetic conservation of isolated populations which occur at the edge of the natural range. These may be of particular importance at a time of predicted global climatic change in providing a reservoir of adaptation to extreme conditions. These isolated populations are often small in size and can be at risk from a number of pressures so that strategies for their conservation need to be given a high priority.

However, apart from these instances, there does not appear to be any reason to be concerned about the long-term future of Scots pine forests at a European scale. Pollution and natural disturbances may pose localised threats as shown by the market disruption caused by the storms of December 1999. However, the extent of the resource, and its potential value in both financial and non-market terms, indicates that Scots pine forests can provide a major contribution to the economic, environmental and social development of the EU's rural economy in the twenty-first century. The challenge is to develop management systems appropriate to region and site that can provide varied forests to meet social and environmental requirements while maintaining a flow of quality timber to provide revenue for the owner and a product that is competitive in a global market.

The trends for Scots pine forests reported in the replies generally appear to accord with the aims of resolution L2 of the 1998 Lisbon MCPFE on criteria, indicators and operational level guidelines for sustainable forest management. In particular, the increases anticipated in the use of natural regeneration, in the development of mixed species stands, and in the amount of structural diversity, meet the requirements of criterion 4 on «Maintenance, conservation, and appropriate enhancement of biological diversity in forest ecosystems» with particular relevance to the concept area of «biological diversity in production forests». The genetic conservation measures with Scots pine now being discussed within the EUFORGEN network are also in line with this concept area. The weaker areas of compliance seem to occur in the related concept areas of «representative, rare and vulnerable ecosystems» and «threatened species». The questionnaire was not designed to provide information on the extent of protected Scots pine forests in member states, but discussions within the CA suggested that, in general, these were few in number and/or of recent creation. Perhaps as a consequence, there is an impression that less emphasis has been given to the study of the component species of Scots pine forest ecosystems than the importance of the forest type would appear to warrant. Integrating such knowledge as exists into management prescriptions will be important to ensure that silvicultural trends reported from most member states provide for the maintenance and enhancement of biological diversity in the most cost-effective way.

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RESUMEN

Estado actual y futuro de Pino silvestre (Pinus sylvestris L.) en Europa: un consenso de esta Acción Concertada

Durante el siglo XX, ha habido una expansión importante en el área del Pino silvestre en Europa de tal forma que este tipo de bosque excede actualmente el 20 % del área productiva forestal de la UE. Aunque el objetivo principal de esta expansión fue el de aumentar la producción de madera, durante las décadas recientes

han cobrado importancia una gama más amplia de objetivos en la gestión. Estos cambios pueden afectar la condición futura y el desarrollo de los bosques de Pino silvestre. Para analizar los impactos potenciales, se distribuyó un cuestionario entre los participantes de la Acción Concertada sobre biodiversidad de Pino silvestre, para comparar el presente y la situación futura de los bosques de Pino silvestre en diferentes países europeos.

Los resultados mostraron que el papel desempeñado por el Pino silvestre en diferentes países de Europa varía desde el de una especie piñonera de plantación sobre tierras agrícola degradadas, hasta ser el componente dominante de un ecosistema forestal nativo. Hay una expectativa general de un movimiento desde los sistemas simples de gestión hacia una selvicultura más compleja basada en el uso mayor de la regeneración natural y con una mayor diversidad de edades y especies. Este movimiento es probable que sea más pronunciado en la Europa central y occidental donde el retorno económico de la gestión actual es bajo. Estos cambios probablemente tendrán beneficios para la biodiversidad, particularmente donde son acompañados por el aumento en la provisión de madera muerta. Hasta recientemente, los estudios sobre la genética en Pino silvestre han puesto el mayor énfasis en mejorar características de crecimiento para mejorar la producción de madera. Existen programas de mejora exitosos en un número de Estados miembros de la UE que indican ganancias potenciales del 10-20 % en el volumen. Sin embargo, se ha aumentando el interés por la conservación de poblaciones aisladas que se encuentran bajo condiciones ambientales extremas para la especies y que tiene importancia potencial en el mantenimiento de la diversidad genética. Algunas de estas poblaciones están amenazadas y se requieren acciones para salvaguardar su futuro.

A pesar de estos cambios, el Pino silvestre continuará siendo la especie forestal más importante en Europa para el futuro previsible. Los cambios previstos en las prácticas de gestión están conformes con las recomendaciones de las resoluciones sobre la gestión sostenible de los bosques realizadas en 1998 en la Conferencia Ministerial de Lisboa sobre la Protección de Bosques en Europa. El desafío es el de desarrollar los sistemas de gestión que son económicamente viables, pero que proporcionan la gama de beneficios no comerciales requeridos por las necesidades de la gestión sostenible del bosque.

PALABRAS CLAVE: Pino silvestre
Selvicultura
Conservación genética
Tendencias futuras

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APPENDIX I

QUESTIONNAIRE ON WHICH THE REPORT IS BASED

The objective of the questionnaire is to analyse the current and future status of Scots pine in Europe.

The three main lines of interest are intended to ascertain the potential impact of various national or provincial forest policies in Europe upon:

a. the current and future status of Scots pine forests?
b. the structure of Scots pine forests?
c. the preservation of isolated/endangered populations?

a. The current and future status of Scots pine forests.

1. What is the current area of Scots pine forest and its age-class distribution (distinguish pure and mixed stands if possible).
2. Is this area the same as/more than/less than in 1900? If there have been major changes, please indicate the main reasons?
3. Do you expect the current area to increase/decrease/stay the same in 2100? Please give reasons.
4. Level of timber production for Scots pine forests and main uses.
5. Objectives of management (general and/or specific to Scots pine forests).
6. Aspects of biodiversity specific to Scots pine forests (e.g. species of conservation value known to be dependent on pinewood ecosystems).
7. What are the main threats to Scots pine forests in your country? Tick all that apply.

- ❑ Fire
- ❑ Disease
- ❑ Conversion to agriculture
- ❑ Conversion to other forest types
- ❑ Overgrazing (e.g. by cattle, sheep, deer)
- ❑ Conversion to housing
- ❑ Pollution
- ❑ Other (please describe)

8. Are there grants or other financial support mechanisms specifically designated for the management of Scots pine forests?
9. If known, what percentage of the Scots pine forests are in public or private ownership? («Public» includes the state, communities and NGO»s; «private» includes corporations, farmers etc.)
10. Is there a tree-breeding programme for Scots pine in your country? If yes, how many breeding populations are there? Is improved material in commercial use and what percentage of planting does this represent? What level of genetic gain is expected?

b. The structure of Scots pine forests

1. Mixed stands

What are the main species occurring in mixture with Scots pine? What is the percentage of mixed stands and do you expect this to change by 2100?

2. Silvicultural systems

Indicate all those that are used in your country and, if possible, estimate the percentage usage of each one. Do you expect this to change by 2100?

❑ Clear cutting
❑ Seed Tree
❑ Uniform shelterwood
❑ Strip shelterwood
❑ Group shelterwood
❑ Irregular shelterwood.
❑ Group selection
❑ Single stem selection
❑ Other (name)

3. What is the percentage of planting compared with natural regeneration? Do you expect this to change by 2100?

4. What are the main natural disturbances (i.e. wind, fire, etc.) to the structure of Scots pine forests and what is the return period?

5. What are the normal rotation ages? Do you expect these to change by 2100?

c. The preservation of isolated/endangered populations.

1. Importance of isolated/endangered populations of Scots pine

2. Afforestation programmes and measures: use of native sources, and non-native sources. Are there any measures to favour the use of native sources of Scots pine in your country?

3. Endangered populations. If there are endangered populations in your country, please indicate which of the following are important.

❑ small size of native populations
❑ difficulties in natural regeneration
❑ environmental stresses
❑ hybridisation with exotic seed sources
❑ other (describe)

4. Genetic resource conservation. Is there a programme in this area in your country covering Scots pine? (Do NOT include conventional tree breeding here.)

5. Main measures of genetic resource conservation. Indicate if these apply to Scots pine in your country?