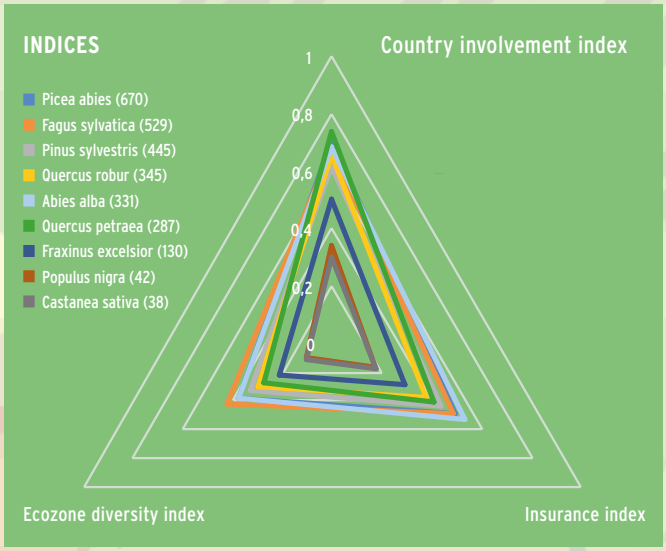
EUFORGEN

Dynamic conservation and utilization of forest tree genetic resources

Indicators for *in situ* and *ex situ* genetic conservation and forest reproductive material



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EFI

Dynamic conservation and utilization of forest tree genetic resources: indicators for *in situ* and *ex situ* genetic conservation and forest reproductive material

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European Forest Genetic Resources Programme (EUFORGEN) is an instrument of international co-operation promoting the conservation and appropriate use of forest genetic resources in Europe. It was established in 1994 to implement Strasbourg Resolution S2 adopted by the first Ministerial Conference of the FOREST EUROPE process, held in France in 1990. EUFORGEN also contributes to implementation of other FOREST EUROPE commitments on forest genetic resources and relevant decisions of the Convention on Biological Diversity (CBD). Furthermore, EUFORGEN contributes to the implementation of regional-level strategic priorities of the Global Plan of Action for the Conservation, Sustainable Use and Development of Forest Genetic Resources (GPA-FGR), adopted by the FAO Conference in 2013. The Programme brings together experts from its member countries to exchange information and experiences, analyse relevant policies and practices, and develop science-based strategies, tools and methods for better management of forest genetic resources. Furthermore, EUFORGEN provides inputs, as needed, to European and global assessments and serves as a platform for developing and implementing European projects. EUFORGEN is funded by the member countries and its activities are mainly carried out through working groups and workshops. The EUFORGEN Steering Committee is composed of National Coordinators nominated by the member countries. The EUFORGEN Secretariat is hosted by the European Forest Institute (EFI). Further information on EUFORGEN can be found at www.euforgen.org.

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PREFACE

Developed and endorsed by Forest Europe, indicator 4.6 on genetic resources of the pan-European criteria and indicators for sustainable forest management[1] is a functional tool to assess and support the conservation of forest genetic resources (FGR) at the pan-European level.

Since 2003, the European Forest Genetic Resources Programme (EUFORGEN) has been responsible for collecting and presenting data on the conservation status of forest genetic resources for the State of Europe's Forest (SoEF) report under indicator 4.6.

Until 2015, European countries were reporting the number of hectares managed for the conservation and utilisation of forest tree genetic resources, across a network of Genetic Conservation Units (GCUs) and area managed for seed production.

At its 11th meeting (November 2015), the EUFORGEN Steering Committee noted that an assessment based on the number of hectares was not appropriate for evaluating status and progress of FGR conservation in Europe and for monitoring changes. They argued that the indicator in use did not give information about the amount of genetic diversity conserved within each country or about the added contribution of within-country conservation units to the overall genetic diversity conserved at the pan-European scale. Moreover, the information on genetic resources was not harmonised among countries; therefore, it was not possible to assess the conservation of FGR in Europe as a whole.

In 2015, the Steering Committee decided to revise indicator 4.6 so that a proper assessment of the conservation of forest genetic resources could be carried out at pan-European level. A Working Group (the authors of this report) was subsequently established to undertake the work.

[1] https://foresteurope.org/sfm-criteria-indicators2/

The Working Group presented a first version of the revised indicator to the Steering Committee at its 12th meeting in May 2017. The National Coordinators provided suggestions and recognised the impossibility at that time of formulating the component of the indicator which would assess "static *ex situ* conservation". They agreed that this component could be developed in due course, in collaboration with the wider plant genetic resources community.

The working group finalised the report in 2017 and opened it to a wider group of experts within the EUFORGEN community for comments. In particular, we acknowledge the contributions received from Kristel Järve (Estonia) and Jutta Buschbom (Germany) who provided constructive feedback on the revised approach.

At its 13th meeting in June 2018, the Steering Committee endorsed the revised indicator as formulated by the Working Group. The Chair of the Working Group, in consultation with Working Group members, incorporated the received feedback.

The draft revised indicator was presented by the EUFORGEN Secretariat at the Second meeting of the Advisory Group - in preparation for the State of Europe's Forests Report 2020 - on 21 and 22 November 2018, in Vienna, Austria, where it was unanimously welcomed.

During the 14th meeting of the Steering Committee (April 2019), the EUFORGEN Secretariat gave a demonstration of the possible assessment of FGR conservation in Europe based on the revised indicator. All member countries and associated countries received data extracted from the EUFGIS information system for revision from the Secretariat. The compiled data was used as a basis for reporting to FOREST EUROPE for the SoEF 2020.

The process described in this page covers five years, but that which led to the formulation of this revised indicator started 25 years ago, as soon as EUFORGEN was established. This is a story of mutual capacity building between countries and of creating common understanding among scientists; a process which has led to the development of the pan-European conservation strategy and its implementation throughout Europe, with the contribution of scientist, practitioners and policy makers involved in EUFORGEN activities.

The revision of this indicator is a successful example of pan-European collaboration: from now on, it will be possible to make a very precise and sound assessment of the real situation in forest genetic conservation in Europe and to monitor any progress in sustainable forest management.

Michele Bozzano, EUFORGEN Coordinator,
February 2020

CONTENTS

DISCLAIMER

Within the Forest Europe set of indicators[2], the proposed revised indicator 4.6 (Genetic resources) aims to support forest genetic resources (FGR) conservation strategies at the pan-European level. It is based on common standard indexes provided at national levels and comprises verifiers in order to quantify the conservation efforts and assess the conservation strategies in multiple dimensions.

These verifiers are designed to serve a specific function and, as presented here, are **not recommended** for other purposes. In particular they should not be used for:

- **Evaluating (or monitoring) priorities in the national conservation strategies**. The verifiers provide a common standard assessment of the overall achievements in FGR conservation scaling for each axis of the strategy. They must therefore be considered jointly and not independently (to improve the achievements, the countries may decide to prioritise efforts in one or the other direction);

- **Evaluating individual national strategies based on high resolution environmental zoning or specific genetic information.** In such cases, additional verifiers providing more detailed insight are needed, using the most appropriate information for the given country (e.g., using higher resolution environmental zoning or taking into account additional levels of genomic information).

[2] https://foresteurope.org/sfm-criteria-indicators2/

EXECUTIVE SUMMARY

A set of Criteria and Indicators (C&I) for sustainable forest management was adopted by the Forest Europe process as a tool to aid forest policy formulation and decision making, forest monitoring and communication. Six criteria reflect complementary aspects of sustainable forest management in the pan-European region. These are currently being assessed (2019) by a set of 34 quantitative and 11 qualitative indicators.

Indicator 4.6 is a quantitative indicator which contributes to Criterion 4 (Maintenance, conservation and appropriate enhancement of biological diversity in forest ecosystems) by focusing on the conservation and use of genetic resources. Between 2016 and 2019 the indicator was revised by a working group established by the EUFORGEN Programme, with the aim of addressing a number of shortcomings in the existing system.

The report, *Revised indicator on genetic resources (4.6) of the pan-European criteria and indicators for sustainable forest management*, addresses the reasoning behind the revision of the indicator and provides details regarding its composition and the reporting of conservation efforts linked to each of the sub-indicators.

The revised indicator comprises four sub-indicators:

1. **Dynamic conservation (*in situ* and *ex situ*) of native species populations;**
2. **Dynamic conservation (*ex situ*) of populations of non-native species;**
3. **Static *ex situ* conservation;**
4. **Forest reproductive material production;**

resulting in informative and comparable verifiers and therefore an improvement in its overall reliability, robustness and resolution. Temporal monitoring of progress made can be carried out using EUFORGEN's synthetic radar chart representation.

To ensure the effective use of the revised indicator, the working group gives a number of recommendations:

- EUFORGEN member countries should continue to implement and further develop the Pan-European strategy for genetic conservation of forest trees.
- Through the EUFORGEN Programme, member countries should work together to develop an agreed set of "minimum requirements" for static *ex situ* conservation.
- Countries should support the development of the national lists of native tree species occurring in each country.

With over twenty years of experience in FGR conservation and ten years in managing the EUFGIS information system on *in situ* conservation units of FGR in Europe, EUFORGEN can guarantee the reliability, specificity, relevance and usefulness of the revised indicator and sub-indicators, which come with a set of more precise definitions and standard scales.

INTRODUCTION

A set of Criteria and Indicators (C&I) for sustainable forest management was adopted by the Forest Europe process as a tool to aid forest policy formulation and decision making, forest monitoring and communication. Six criteria reflect complementary aspects of sustainable forest management in the pan-European region. These are currently being assessed (2019) by a set of 34 quantitative and 11 qualitative indicators[3].

The quantitative indicators provide information on the current status and changes in European forests and can be used to monitor progress in sustainable forest management. Via a range of means (policies, institutions, regulatory and financial instruments, information), the changes reported in the qualitative indicators over time reflect the responses of policy-makers to challenges and opportunities related to forests and sustainable forest management.

Criterion 4 describes the "Maintenance, conservation and appropriate enhancement of biological diversity in forest ecosystems".

It is evaluated using ten quantitative indicators and one qualitative indicator. Indicator 4.6, a quantitative indicator which focuses on genetic resources, is justified as follows: "*The conservation and use of forest genetic resources is a vital component of sustainable forest management. Genetic diversity ensures that forest trees can survive, adapt and evolve under changing environmental conditions. Genetic diversity is also needed to maintain the vitality of forests and cope with pests and diseases*" (State of Europe's Forests 2015).

Until now, indicator 4.6 has consisted of three sub-indicators: the area managed for *in situ* conservation, the area managed for *ex situ* conservation and the area managed for seed production. European countries have been reporting the area in hectares managed for the conservation and utilisation of forest tree genetic resources and the area managed for seed production.

Reliable, informative and robust verifiers, which provide sufficient resolution, are needed in order to evaluate the current state of the indicator and its sub-indicators. However, we do not consider the assessment based on the number of hectares to provide a sufficiently infor-

[3] https://www.foresteurope.org/wp-content/uploads/2017/03/CI_4pages.pdf

mative means of evaluating the status of Forest Genetic Resources (FGR) in Europe, nor of monitoring progress towards their conservation. This is because it provides no indication of the fraction of genetic diversity conserved within each country, nor of the contribution that within-country conservation units make to the overall genetic diversity conserved at the pan-European scale. It also does not provide a sufficient measure with which to assess progress over time in the conservation of genetic diversity. Moreover, the analysis of current information reveals a lack of harmonisation among countries regarding the type of genetic resources included, due to which a meaningful comparison cannot be obtained.

In order to address the above-mentioned shortcomings in the current system, a working group has been established by EUFORGEN to revise the indicator on genetic resources conservation and use. On the basis of over twenty years of experience in FGR conservation and ten years in managing the EUFGIS information system on *in situ* conservation units of FGR in Europe, EUFORGEN guarantees that the revised indicator and sub-indicators are reliable, specific, simple, relevant and useful. They come with a set of more precise definitions and standard scales.

It is generally recognised that using a single numeric value for each country will not result in a comprehensive assessment. We therefore propose that the indicator be composed of a set of four sub-indicators corresponding to four simple values. In addition, our synthetic radar chart representation illustrates the indicator globally, thereby allowing temporal monitoring of progress to be made per country and species, as well as at the continental level.

In order to obtain a meaningful comparison of different strategies among countries or species, and to monitor progress, the sub-indicators are expressed as ratios whenever possible; values range between 0 and 1, where 0 means no conservation activities in the area and 1 means fully achieved conservation activity in the area.

Data on three of these four sub-indicators can be retrieved retrospectively as far back as 2010 from the EUFGIS database.

REVISED INDICATOR ON GENETIC RESOURCES

The rationale behind the revised indicator 4.6 on the conservation and use of forest genetic diversity remains unchanged. However, it comprises four, rather than three, sub-indicators in order to improve reliability and specificity, and, more precisely, to capture, distinguish and represent the different components of genetic resources. This results in more informative and comparable verifiers, and therefore an improvement in the overall reliability, robustness and resolution (specificity and sensitivity) of the revised indicator.

The four sub-indicators are as follows:

1. Dynamic conservation (*in situ* and *ex situ*) of native species populations
2. Dynamic conservation (*ex situ*) of non-native species populations
3. Static *ex situ* conservation
4. Forest reproductive material production

In order for conservation efforts to be assessed and monitored, all countries will report species data in two ways: first, across species per country and, second, across countries per species at continental level.

The EUFORGEN National coordinators, via the EUFGIS Focal Points[4], are responsible for reporting conservation efforts regarding native and non-native species that occur in their respective countries. **Native species populations** are local populations of species which are officially recognised as part of the natural flora of the country and which have evolved locally through at least one generational turnover. They can be conserved *in situ*, i.e., at their place of origins, or *ex situ*, i.e., a representative sample of individuals is transplanted to another site within the country or to another country. **Non-native species populations** relevant to the purpose of this indicator are either those that were introduced from exotic species to Europe or those that are non-native in the country, which have undergone at least one generational turnover of *in situ* natural regeneration.

The reference list of priority species for which conservation is monitored is presented in Annex 1 and will be made available via the EUFGIS portal.

Dynamic conservation of populations of native forest tree species (including *in situ* and dynamic *ex situ*) as genetic resources

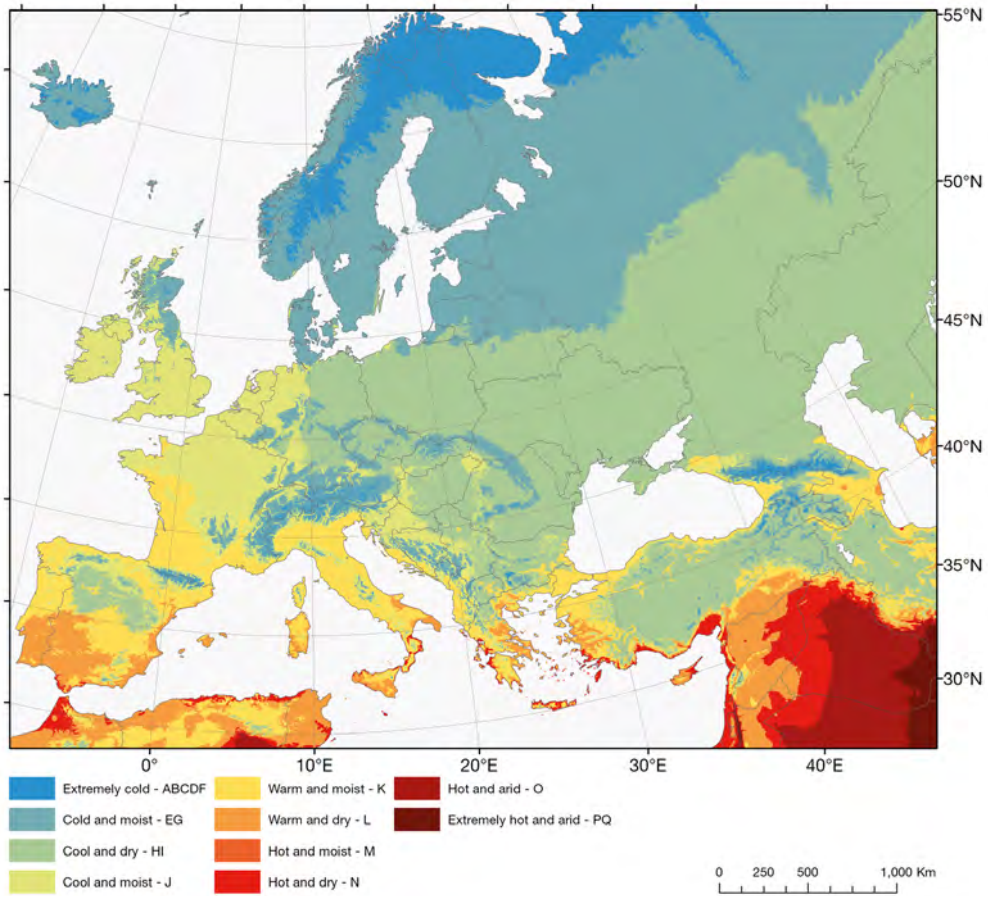
Comprehensive data on genetic diversity and its pattern of distribution across European forests is only available for a very limited number of species. To com-

[4] http://portal.eufgis.org/data-providers

pensate for this lack of knowledge, we have made the following assumptions: local adaptation is a general feature in tree populations (Savolainen *et al.*, 2007) and where native species occur naturally, their adaptive genetic diversity is likely to reflect the ecological conditions in which they grow. Efforts should therefore be made to conserve representative populations of each native species, as well as selected non-native species and *ex situ* populations which are present in each environmental zone. This should be done by following the Pan-European strategy for genetic conservation of forest trees set out by de Vries *et al.* (2015).

To use this proxy for sub-indicators 1 and 2 (dynamic conservation) appropriately, each country has to provide

FIGURE 1. Map of environmental zones occurring in Europe following the classification from Metzger *et al.* (2013) modified by de Vries *et al.* (2015).



the number of native species and environmental ecological zones within each species distribution area, as well as information about their potential adaptive characteristics. De Vries *et al.* (2015) defined a modified classification of the environment in Europe based on Metzger *et al.* (2013). The modified classification consists of a total of eight environmental zones for Europe.

The list of environmental zones for each country is provided in Annex 2.

The *Pan-European strategy for genetic conservation of forest trees* defines a classification and assessment approach to genetic conservation activities based on political borders and environmental zones in each country. This allows each genetic conservation unit in a given country to

TABLE 1. Definitions of the verifiers related to the dynamic conservation of native populations of forest tree species as genetic resources.

Value or verifiers	Definition	Observation
Dynamic conservation effort ***(nb_populations)***	total number of conserved populations in Genetic Conservation Units (GCU) in the country	This value is important for monitoring conservation activities at national level, since it is not influenced by pan-European classification and prioritisation
Species diversity index ***(ind_species)***	number of species listed as target species in genetic conservation units / number of priority species occurring within the country	The index is calculated based on the priority species listed in Annex 1, occurring in the country
Ecozones diversity index ***(ind_ecozones)***	number of ecozones represented in the national conservation network / number of ecozones occurring within the country* (summed over conserved species only)	The index is calculated based on the species conserved in the country and the existing environmental zones per species in the country.
Insurance index ***(ind_insurance)***	number of ecozones represented in the conservation network with a minimum number of 2 units / number of ecozones occurring within the country* (summed over conserved species only)	The index is calculated based on the species conserved in GCUs in the country and the existing environmental zones in the country.

* In a first round, the number of ecozones occurring in each country will be automatically computed by overlaying species distribution maps and environmental zones. Artifactual ecozones which could result from automatic GIS computation will be progressively removed based on national expertise.

be classified in terms of its membership of an environmental zone on the basis of its location on the map in Figure 1.

In order to properly assess the dynamic conservation of forest tree genetic resources derived from native species populations, countries should report four verifiers:

- Dynamic conservation effort (***nb_populations***).
- Species diversity index (***ind_species***)
- Ecozones[5] diversity index (***ind_ecozones***).
- Insurance index (***ind_insurance***).

Retrospective data to report on this sub-indicator are available as far back as 2010 in the EUFGIS information system. An example is provided in Annex 3.

Dynamic conservation of populations of non-native forest tree species as genetic resources

Non-native populations (i.e., introduced populations that have had at least one generational turnover in natural regeneration in the country), have had little time to evolve in their current locations, even when occurring in several environmental zones. Nevertheless, these populations may have particular characteristics and contain valuable genetic resources; both local adaptation and random genetic evolution are presumed for these populations (both evolutionary forces always co-exist, but in this short-term evolutionary timescale, we expect random evolution to have an important role and structuration of genetic diversity by ecozones not to be fully achieved). Therefore, while the conservation effort of non-native species is to be recognised, only the total number of conserved populations must be reported by each country.

Countries will report the following verifier:

- Number of dynamic conservation populations of non-native species (***nb_units_non_native***)

Retrospective data to report on this sub-indicator are available as far back as 2010.

An example is provided in Annex 4

Static *ex situ* conservation

Static *ex situ* conservation efforts will be reported as the number of collections, which include clonal archives and genebank collections meeting minimum requirements. Data will be reported for native and non-native species.

Countries will report the following verifier:

- Number of collections (including clonal archives and genebank collections meeting the minimum requirements)

[5] "Ecozones" are in this context defined as the different environmental zones where the different species occur in each country (e.g., two species that occur in two and four environmental zones respectively represent a total of six ecozones).

To date, November 2019, it has not been possible to formulate the minimum requirements for static *ex situ* conservation. The EUFORGEN programme is undertaking a consultative process that aims to define these requirements. Until this is completed, countries will not report on static *ex situ* conservation in the framework of this indicator.

Potential for the production of Forest Reproductive Material

Forest Reproductive Material (FRM) can consist of fruits, seeds and cones, as well as all parts of plants obtained by vegetative propagation, including embryos, and plants produced from any of these. For those species that are regulated under council directive 1999/105/EC, marketable reproductive material has to come from registered basic material.

There are four categories of reproductive material according to the Basic Material from which it is derived:

- **Source-identified** FRM comes from basic material which is either a seed source or stand located within a single region of provenance, with no recognised superior qualities.
- **Selected** FRM comes from registered stands which are selected based on their superior phenotypic characteristics, e.g., better form, growth rate, health.
- **Qualified** FRM comes from designed populations (seed orchards, parents of families, clonal mixtures) or clones, where the individuals have been phenotypically selected for their outstanding characters.
- **Tested** FRM comes from designed populations where the components have been genetically evaluated and proven to be superior. Alternatively, the superiority of the reproductive material itself may be shown through comparative testing.

Countries will report the following verifiers:

- Total number of FRM production units (for each of the 4 categories).
- Total number of species for which there is at least one FRM production unit.

Data will be reported for all species for which there are available data. In the European Union, for the 48 species listed in Annex 1 of the COUNCIL DIRECTIVE 1999/105/EC of 22 December 1999 on the marketing of forest reproductive material (cp. Annex 1), specific recording is required; for other non-listed species there may be additional ongoing recording in individual countries. These will all be reported per species.

Retrospective data to report on this sub-indicator are available as far back as 2015 in the FOREMATIS Information system, but countries have been collecting and reporting using this approach since 1999.

An example is provided in Annex 5.

DATA SOURCES

Data for populating the indicator can be obtained from existing information systems, databases and national registers. For example, information on species and country *in situ* and *ex situ* efforts can be retrieved from the EUFGIS information system, while information on forest reproductive material production is available from the FOREMATIS information system.

EUFGIS Information System (sites managed for the conservation of forest tree genetic resources)

Since the establishment of the European Information System on Forest Genetic Resources (EUFGIS) in 2010, European countries have started to follow the "pan-European minimum requirements for dynamic genetic conservation units of forest trees"[6] for the data reported as "area managed for *in situ* conservation".

The minimum requirements are based on the concept of dynamic conservation of genetic diversity, which emphasises the maintenance of evolutionary processes within tree populations to safeguard their potential for continuous adaptation. The units entered into the EUFGIS database have a designated status as genetic conservation areas of forest trees at national level. The minimum requirements also specify a minimum size of a unit, depending on tree species and conservation objectives. 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 reduce genetic erosion and enhance adaptive processes within target tree populations.

The EUFGIS information system is regularly maintained by National Focal Points in European countries. On 3 December 2017, the EUFGIS database contained information on 3390 units and 101 tree species in 34 countries. The units contain a total of 4301 tree populations.

Since 2010, the EUFGIS information system has been used as a source of data for assessing *in situ* genetic conservation activities in Europe. The EUFORGEN programme will provide support to countries that have not entered data into EUFGIS in the form of ad-hoc training and helpdesk access.

[6] http://portal.eufgis.org/fileadmin/templates/eufgis.org/documents/EUFGIS_Minimum_requirements.pdf

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The EUFGIS information system is also a source of data for *ex situ* dynamic conservation. *Ex situ* genetic conservation units consist of stands and clone collections established with collected or multiplied genetic material.

FOREMATIS Information System (Potential for the production of Forest Reproductive Material)

The Council directive of 22 December 1999 on the marketing of forest reproductive material[7] lays down rules for tree seed and plant stock production in the EU. In order to harmonise data across EU Member States, the EC Directorate General for Health and Food Safety (DG SANTE) developed the Forest Reproductive Material Information System (FOREMATIS)[8], an information system on approved planted forest tree species. Released in 2016, FOREMATIS provides a search tool for forest tree breeders, forestry nursery staff, experts and the general public, functioning as a repository of Member State data of regulated planted forest tree species.

FOREMATIS collects information of approved basic material based on EU Member States' national lists. Currently the European Commission is exploring the possibility to open the database to all European tree species[9].

It provides information on the location, origin and type of forest tree species important for the production of high quality and diverse forest reproductive material.

FOREMATIS currently (November 2019) contains information in approximately 90.000 records on 50 tree species. With the information system, EU Member States are able to manage their national lists on the Commission's website. FOREMATIS uses semantic technologies that allow it to be connected to other structured public data sources. The use of these new technologies will create a central hub for a vast amount of information on planted forest tree species in a range of domains.

European Atlas of Forest Tree Species

Since 2016 the European Commission's Joint Research Centre (JRC) maintains the European Atlas of Forest Tree Species, a comprehensive publication which presents the species distribution and suitability maps, of the main European forest tree species.

The atlas is regularly maintained and new chorological maps are regularly produced[10].

Some of these maps are based on previous work of the EUFORGEN programme. The Atlas will be used as primary source of information on species chorology.

[7] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A31999L0105

[8] https://ec.europa.eu/forematis/

[9] Member countries of the OECD Forest Seed and Plant Scheme have been invited to test the system.

[10] https://www.sciencedirect.com/science/article/pii/S2352340917301981?via%3Dihub

RECOMMENDATIONS

- EUFORGEN member countries should continue to implement and further develop the Pan-European strategy for genetic conservation of forest trees.

- Through the EUFORGEN Programme, member countries should work together to develop an agreed set of "minimum requirements" for static *ex situ* conservation.

- Countries should support Botanic Gardens Conservation International (BGCI) via its initiative "GlobalTreeSearch"[11] in the development of the national lists of native tree species occurring in each country.

[11] https://tools.bgci.org/global_tree_search.php

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ANNEXES

ANNEX 1. Pan-European List of priority species for which conservation is monitored

For the assessment of the indicator 4.6, the EUFORGEN Programme has developed a list of priority species, which was compiled by merging the following species lists:

- All species listed in Annex 1 of the COUNCIL DIRECTIVE 1999/105/EC of 22 December 1999 on the marketing of forest reproductive material.

- All species already entered in the EUFGIS Information system as of November 2019.

- All tree species identified as model tree species by the species-Network that were active during Phase II and III of the Programme.

- All tree species for which JRC has developed species distribution maps[12].

When relevant, countries can submit a request to the Secretariat for species not currently listed to be added (following the standard taxonomy listed in the GlobalTreeSearch database, maintained by the Botanic Gardens Conservation International (BGCI)). The decision regarding whether the new species will be added or not will be made by the Steering Committee.

Any addition to the species list will affect the calculation of the indicators retroactively for all the countries in which the species is present. Therefore, each re-computation using the revised species list will be linked to the previous version to ensure proper comparison and to monitor real progress.

[12] https://forest.jrc.ec.europa.eu/en/european-atlas/atlas-data-and-metadata/

COMPILED LIST FOR GEOGRAPHICAL EUROPE:

*Abies alba**
Abies borisii-regis
Abies bornmuelleriana
*Abies cephalonica**
Abies cilicica
Abies equi-trojani
*Abies grandis**
Abies marocana
Abies nebrodensis
Abies nordmanniana
Abies numidica
*Abies pinsapo**
Acer campestre
Acer lobelii
Acer monspessulanum
Acer opalus
*Acer platanoides**
*Acer pseudoplatanus**
Acer tataricum
Acer trautvetteri
Aesculus hippocastanum
Ailanthus altissima
Alnus cordata
*Alnus glutinosa**
*Alnus incana**
Alnus orientalis
Alnus viridis
Arbutus unedo
Berberis vulgaris
*Betula pendula**
*Betula pubescens**
Buxus balearica
Buxus sempervirens
*Carpinus betulus**
Carpinus orientalis
Carya ovata
*Castanea sativa**
*Cedrus atlantica**
*Cedrus libani**
Celtis australis
Cornus mas
Cornus sanguinea
Corylus avellana
Corylus colurna
Cotoneaster integerrimus
Cotoneaster melanocarpus
Crataegus laevigata
Crataegus monogyna
Crataegus rhipidophylla
Cupressus sempervirens
Fagus orientalis
*Fagus sylvatica**
Fagus taurica
Frangula alnus
Fraxinus americana
*Fraxinus angustifolia**
*Fraxinus excelsior**
Fraxinus ornus
Fraxinus pennsylvanica
Gleditsia triacanthos
Hippophae rhamnoides
Ilex aquifolium
Juglans nigra
Juglans regia
Juniperus communis
Juniperus excelsa
Juniperus foetidissima
Juniperus oxycedrus
Juniperus phoenicea
Juniperus thurifera
Laburnum anagyroides
*Larix decidua**
*Larix kaempferi **
*Larix sibirica **
Liquidambar orientalis
Lonicera periclymenum
Lonicera xylosteum
Malus sylvestris
Morus alba
Olea europaea
Ostrya carpinifolia

* Species under Annex 1 of the COUNCIL DIRECTIVE 1999/105/EC of 22 December 1999 on the marketing of forest reproductive material.

Phoenix theophrasti
*Picea abies**
Picea omorika
Picea orientalis
*Picea sitchensis**
*Pinus brutia**
*Pinus canariensis **
*Pinus cembra**
*Pinus contorta**
*Pinus halepensis**
*Pinus heldreichii**
Pinus mugo
*Pinus nigra**
Pinus peuce
*Pinus pinaster**
*Pinus pinea**
*Pinus radiata**
Pinus strobus
*Pinus sylvestris**
Pinus uncinata
Pistacia atlantica
Pistacia terebinthus
Pistacia mutica
Platanus orientalis
*Populus alba**
*Populus nigra**
*Populus tremula**
*Prunus avium**
Prunus cerasifera
Prunus mahaleb
Prunus padus
Prunus spinosa
*Pseudotsuga menziesii**
Pterocarya fraxinifolia
Pyrus communis
Pyrus pyraster
*Quercus cerris**
Quercus coccifera
Quercus frainetto
*Quercus ilex**
Quercus palustris
Quercus pedunculiflora
*Quercus petraea**
*Quercus pubescens**
Quercus pyrenaica
*Quercus robur**
*Quercus rubra**
*Quercus suber**
Quercus trojana
Quercus virgiliana
Quercus virginiana
Quercus vulcanica
Rhamnus cathartica
*Robinia pseudoacacia**
Salix alba
Salix caprea
Salix cinerea
Salix fragilis
Salix myrsinifolia
Salix pentandra
Salix rosmarinifolia
Sambucus nigra
Sorbus aria
Sorbus aucuparia
Sorbus domestica
Sorbus intermedia
Sorbus torminalis
Styphnolobium japonicum
Taxodium distichum
Taxus baccata
*Tilia cordata**
*Tilia platyphyllos**
Tilia tomentosa
Ulmus foliacea
Ulmus glabra
Ulmus laevis
Ulmus minor
Ulmus pumila
Viburnum opalus

Non-native species (i.e., introduced species that have had at least one generational turnover in natural regeneration in Europe), are also listed here.

ANNEX 2. Environmental zones in each country

Country	Environmental zone name	Environmental zone code
Albania	Extremely cold	ABCDF
	Cold and moist	EG
	Cool and dry	HI
	Cool and moist	J
	Warm and moist	K
Andorra	Extremely cold	ABCDF
	Cold and moist	EG
Armenia	Extremely cold	ABCDF
	Cold and moist	EG
	Cool and dry	HI
	Warm and moist	K
Austria	Extremely cold	ABCDF
	Cold and moist	EG
	Cool and dry	HI
	Cool and moist	J
Azerbaijan	Extremely cold	ABCDF
	Cold and moist	EG
	Cool and dry	HI
	Cool and moist	J
	Warm and moist	K
	Warm and dry	L
Belarus	Cold and moist	EG
	Cool and dry	HI
Belgium	Cold and moist	EG
	Cool and moist	J
Bosnia and Herzegovina	Extremely cold	ABCDF
	Cold and moist	EG
	Cool and dry	HI
	Cool and moist	J
	Warm and moist	K

Country	Environmental zone name	Environmental zone code
Bulgaria	Extremely cold	ABCDF
	Cold and moist	EG
	Cool and dry	HI
	Cool and moist	J
	Warm and moist	K
Croatia	Cold and moist	EG
	Cool and dry	HI
	Cool and moist	J
	Warm and moist	K
	Warm and dry	L
Cyprus	Warm and moist	K
	Warm and dry	L
	Hot and dry	N
Czech Republic	Extremely cold	ABCDF
	Cold and moist	EG
	Cool and dry	HI
Denmark	Cold and moist	EG
	Cool and dry	HI
	Cool and moist	J
Estonia	Cold and moist	EG
Finland	Extremely cold	ABCDF
	Cold and moist	EG
France	Extremely cold	ABCDF
	Cold and moist	EG
	Cool and dry	HI
	Cool and moist	J
	Warm and moist	K
Georgia	Extremely cold	ABCDF
	Cold and moist	EG
	Cool and dry	HI
	Cool and moist	J
	Warm and moist	K

Country	Environmental zone name	Environmental zone code
Germany	Extremely cold	ABCDF
	Cold and moist	EG
	Cool and dry	HI
	Cool and moist	J
Greece	Extremely cold	ABCDF
	Cold and moist	EG
	Cool and dry	HI
	Cool and moist	J
	Warm and moist	K
	Warm and dry	L
	Hot and dry	N
Hungary	Cold and moist	EG
	Cool and dry	HI
	Cool and moist	J
Iceland	Extremely cold	ABCDF
	Cold and moist	EG
Ireland	Cold and moist	EG
	Cool and moist	J
Italy	Extremely cold	ABCDF
	Cold and moist	EG
	Cool and dry	HI
	Cool and moist	J
	Warm and moist	K
	Warm and dry	L
	Hot and dry	N
Latvia	Cold and moist	EG
Liechtenstein	Cold and moist	EG
	Cool and moist	J
Lithuania	Cold and moist	EG
	Cool and dry	HI
Luxembourg	Cold and moist	EG
	Cool and moist	J

Country	Environmental zone name	Environmental zone code
Malta	Hot and dry	N
Moldova	Cool and dry	HI
Montenegro	Extremely cold	ABCDF
	Cold and moist	EG
	Cool and moist	J
	Warm and moist	K
Netherlands	Cool and moist	J
North Macedonia	Extremely cold	ABCDF
	Cold and moist	EG
	Cool and dry	HI
	Cool and moist	J
	Warm and moist	K
Norway	Extremely cold	ABCDF
	Cold and moist	EG
	Cool and moist	J
Poland	Extremely cold	ABCDF
	Cold and moist	EG
	Cool and dry	HI
	Cool and moist	J
Portugal	Cool and dry	HI
	Cool and moist	J
	Warm and moist	K
	Warm and dry	L
	Hot and dry	N
Romania	Extremely cold	ABCDF
	Cold and moist	EG
	Cool and dry	HI
	Cool and moist	J
Russia	Extremely cold	ABCDF
	Cold and moist	EG
	Cool and dry	HI
	Cool and moist	J
	Warm and moist	K

Country	Environmental zone name	Environmental zone code
Serbia	Extremely cold	ABCDF
	Cold and moist	EG
	Cool and dry	HI
	Cool and moist	J
	Warm and moist	K
Slovakia	Extremely cold	ABCDF
	Cold and moist	EG
	Cool and dry	HI
	Cool and moist	J
Slovenia	Extremely cold	ABCDF
	Cold and moist	EG
	Cool and dry	HI
	Cool and moist	J
	Warm and moist	K
Spain	Extremely cold	ABCDF
	Cold and moist	EG
	Cool and dry	HI
	Cool and moist	J
	Warm and moist	K
	Warm and dry	L
	Hot and moist	M
	Hot and dry	N
Sweden	Extremely cold	ABCDF
	Cold and moist	EG
	Cool and dry	HI
Switzerland	Extremely cold	ABCDF
	Cold and moist	EG
	Cool and dry	HI
	Cool and moist	J

Country	Environmental zone name	Environmental zone code
Turkey	Extremely cold	ABCDF
	Cold and moist	EG
	Cool and dry	HI
	Cool and moist	J
	Warm and moist	K
	Warm and dry	L
	Hot and dry	N
Ukraine	Extremely cold	ABCDF
	Cold and moist	EG
	Cool and dry	HI
	Cool and moist	J
United Kingdom	Extremely cold	ABCDF
	Cold and moist	EG
	Cool and moist	J

ANNEX 3. Dynamic conservation of populations of native forest tree species (including in situ and dynamic ex situ) as genetic resources - Data presented per Country

TABLE 2. Numerical visualisation: Dynamic conservation effort, Species diversity index, Ecozone diversity index, and Insurance index. (*Source* EUFGIS - November 2019).

Testing Countries	**Dynamic conservation effort**				**Species diversity index**
	Total number of conserved populations in Genetic Conservation Units (GCU) in the country	Number of species occurring within the country (Based on the Pan-European List of priority species, Annex 1)	Number of ecozones per country	Number of target species in GCUs (i.e., conserved species)	Number of species listed as target species in genetic conservation units/ number of species occurring within the country
Denmark	**218**	44	3	21	**0.477**
Estonia	**10**	36	1	3	**0.083**
Finland	**63**	33	2	10	**0.303**
France	**101**	94	5	10	**0.106**
Iceland	**1**	3	2	1	**0.333**
Italy	**222**	104	7	32	**0.308**
Norway	**38**	23	3	10	**0.435**
Poland	**537**	63	4	23	**0.365**
Slovenia	**39**	72	5	22	**0.306**
Spain	**308**	80	8	17	**0.213**

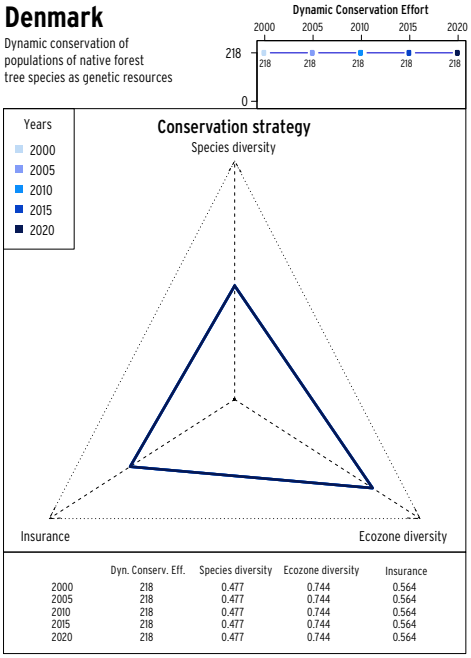
(Table 2 continued)

			Ecozone diversity index	**Insurance index**
Number of ecozones occurring within the country (summed over all conserved species)	Number of ecozones in GCUs	Number of ecozones conserved within a minimum number of 2 GCUs	Number of ecozones represented in the national conservation network /number of ecozones occurring within the country (summed over conserved species only)	Number of ecozones represented in the conservation network with a minimum number of 2 units/number of ecozones occurring within the country (summed over conserved species only)
39	29	22	**0.744**	**0.564**
3	3	2	**1**	**0.667**
14	14	12	**1**	**0.857**
37	19	11	**0.514**	**0.297**
2	1	0	**0.5**	**0**
129	60	38	**0.465**	**0.295**
20	12	11	**0.6**	**0.55**
63	39	33	**0.619**	**0.524**
56	27	9	**0.482**	**0.161**
75	59	51	**0.787**	**0.680**

TABLE 3. Graphical visualisation per country: Scatter plot of Dynamic conservation effort and Radar chart of Species diversity index, Ecozone diversity index, and Insurance index. The numeric values are provided in the table below. (*Source* EUFGIS - November 2019).

Denmark

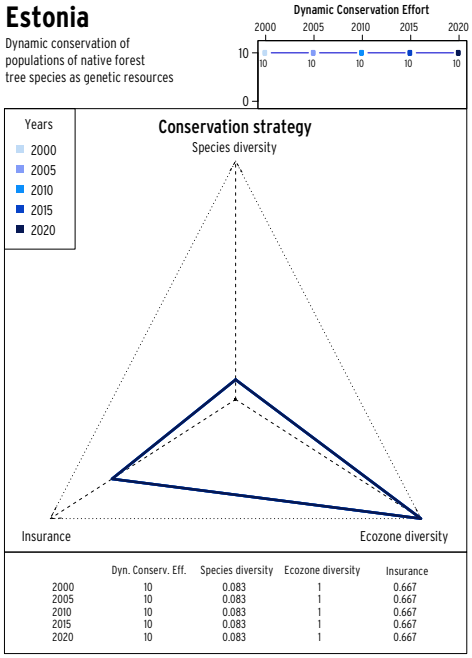
Dynamic conservation of populations of native forest tree species as genetic resources



	Dyn. Conserv. Eff.	Species diversity	Ecozone diversity	Insurance
2000	218	0.477	0.744	0.564
2005	218	0.477	0.744	0.564
2010	218	0.477	0.744	0.564
2015	218	0.477	0.744	0.564
2020	218	0.477	0.744	0.564

Estonia

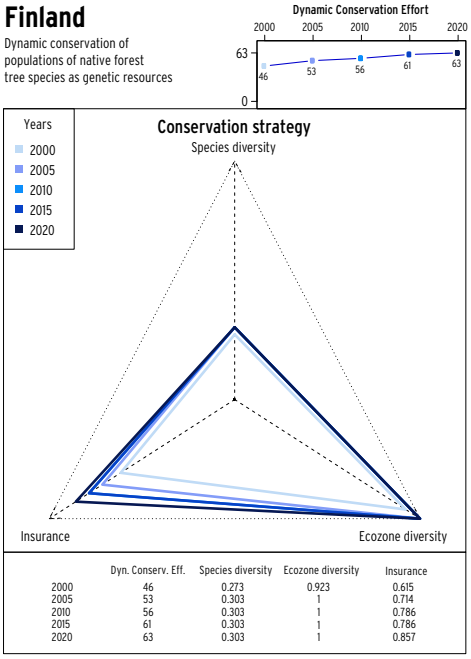
Dynamic conservation of populations of native forest tree species as genetic resources



	Dyn. Conserv. Eff.	Species diversity	Ecozone diversity	Insurance
2000	10	0.083	1	0.667
2005	10	0.083	1	0.667
2010	10	0.083	1	0.667
2015	10	0.083	1	0.667
2020	10	0.083	1	0.667

Finland

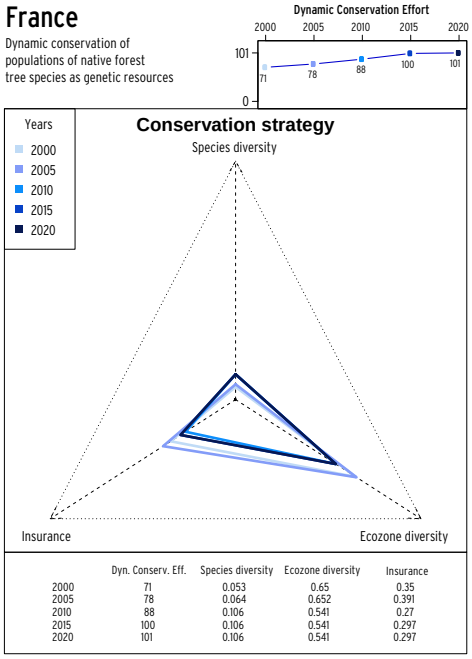
Dynamic conservation of populations of native forest tree species as genetic resources



	Dyn. Conserv. Eff.	Species diversity	Ecozone diversity	Insurance
2000	46	0.273	0.923	0.615
2005	53	0.303	1	0.714
2010	56	0.303	1	0.786
2015	61	0.303	1	0.786
2020	63	0.303	1	0.857

France

Dynamic conservation of populations of native forest tree species as genetic resources

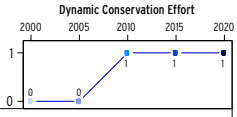


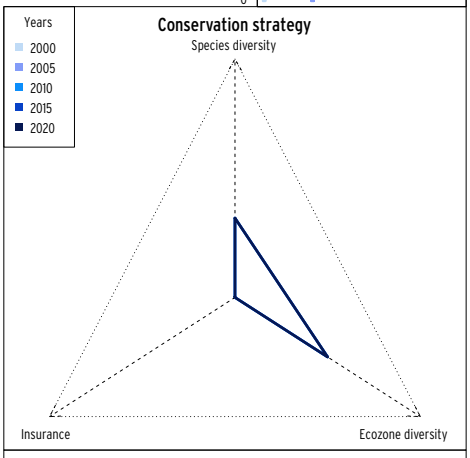
	Dyn. Conserv. Eff.	Species diversity	Ecozone diversity	Insurance
2000	71	0.053	0.65	0.35
2005	78	0.064	0.652	0.391
2010	88	0.106	0.541	0.27
2015	100	0.106	0.541	0.297
2020	101	0.106	0.541	0.297

(Table3. continued)

Iceland

Dynamic conservation of populations of native forest tree species as genetic resources

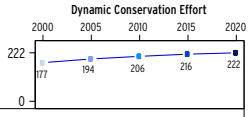


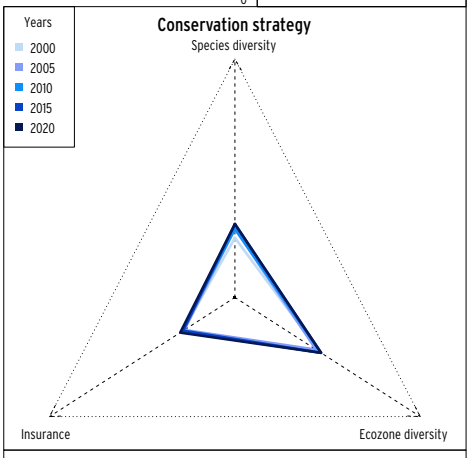


	Dyn. Conserv. Eff.	Species diversity	Ecozone diversity	Insurance
2000	0	0	0	0
2005	0	0	0	0
2010	1	0.333	0.5	0
2015	1	0.333	0.5	0
2020	1	0.333	0.5	0

Italy

Dynamic conservation of populations of native forest tree species as genetic resources

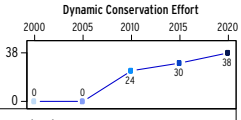


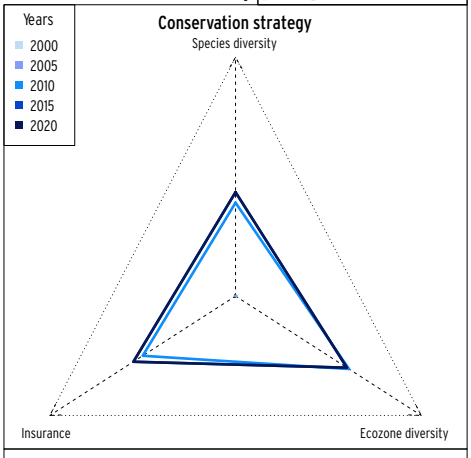


	Dyn. Conserv. Eff.	Species diversity	Ecozone diversity	Insurance
2000	177	0.25	0.456	0.282
2005	194	0.288	0.438	0.273
2010	206	0.288	0.463	0.289
2015	216	0.308	0.465	0.279
2020	222	0.308	0.465	0.295

Norway

Dynamic conservation of populations of native forest tree species as genetic resources

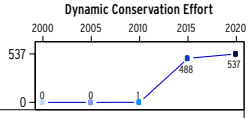


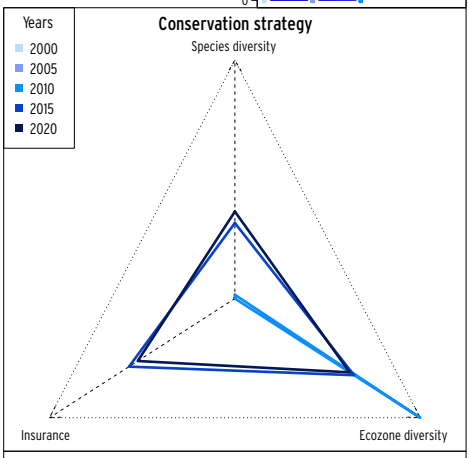


	Dyn. Conserv. Eff.	Species diversity	Ecozone diversity	Insurance
2000	0	0	0	0
2005	0	0	0	0
2010	24	0.391	0.611	0.5
2015	30	0.435	0.6	0.55
2020	38	0.435	0.6	0.55

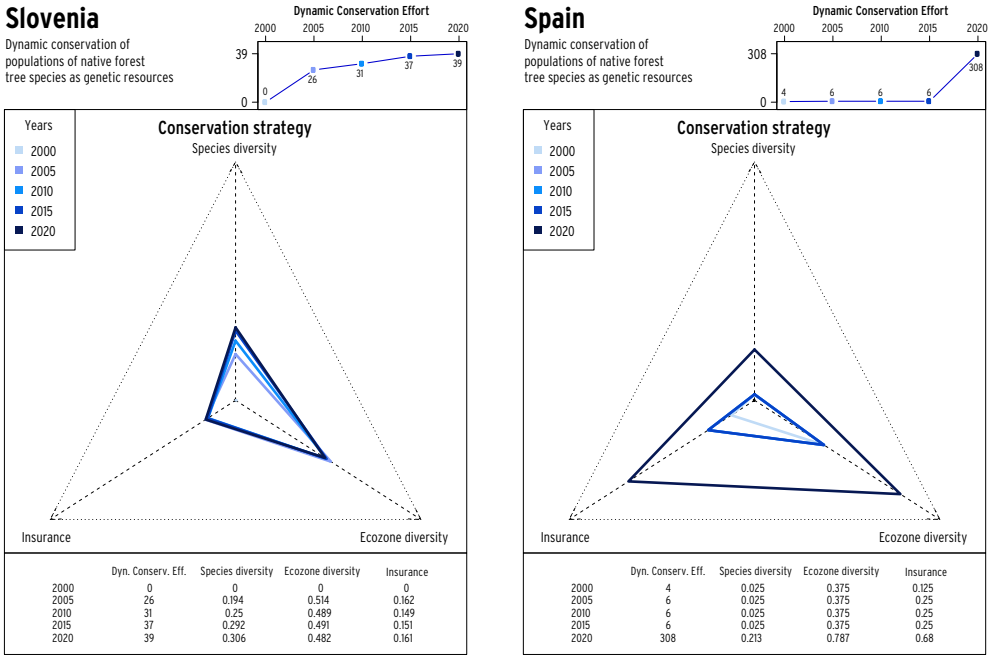
Poland

Dynamic conservation of populations of native forest tree species as genetic resources





	Dyn. Conserv. Eff.	Species diversity	Ecozone diversity	Insurance
2000	0	0	0	0
2005	0	0	0	0
2010	1	0.016	1	0
2015	488	0.317	0.643	0.571
2020	537	0.365	0.619	0.524

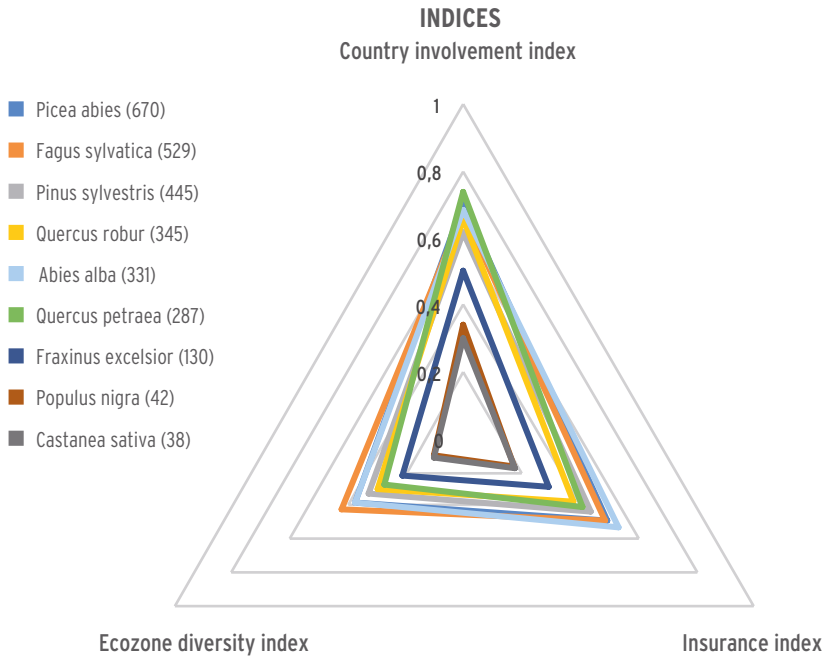


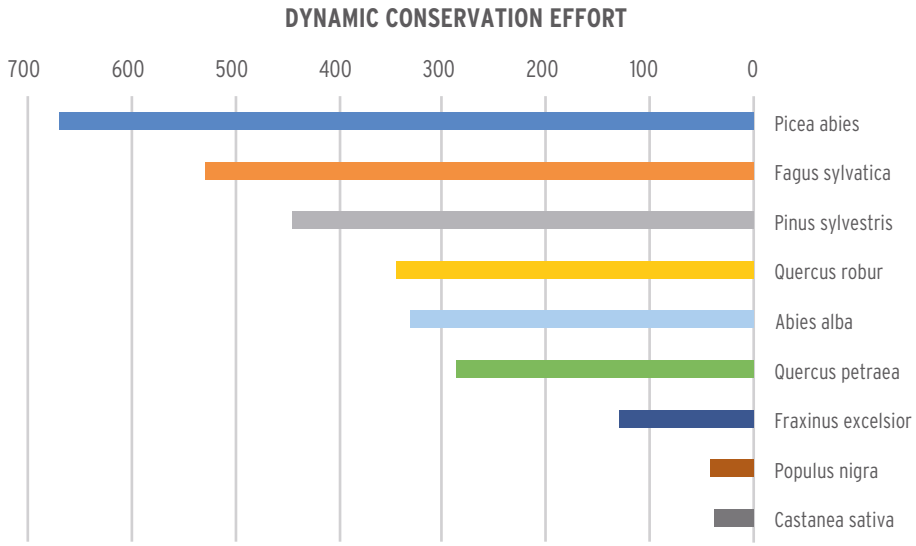
DATA PRESENTED PER NATIVE SPECIES AT A PAN EUROPEAN LEVEL

TABLE 4. Data presented per species at a pan European level - numerical visualisation: Dynamic conservation effort, Country involvement index (nº of countries where the species is conserved/ nº of countries where the species is occurring), Ecozone diversity index, and Insurance index. (*Source* EUFGIS - November 2019).

Species name	Dynamic conservation effort	Country involvement	Ecozone diversity index	Insurance index
Abies alba	331	0.682	0.534	0.379
Castanea sativa	38	0.300	0.176	0.108
Fagus sylvatica	529	0.677	0.489	0.420
Fraxinus excelsior	130	0.500	0.291	0.214
Picea abies	670	0.704	0.494	0.38
Pinus sylvestris	445	0.618	0.436	0.330
Populus nigra	42	0.343	0.172	0.101
Quercus petraea	287	0.735	0.408	0.276
Quercus robur	345	0.658	0.376	0.297

FIGURE 2. Data presented per species at a pan European level - graphical visualisation: Histogram of Dynamic conservation effort and Radar chart of Country involvement index, Ecozone diversity index, and Insurance index for nine European forest tree species. (*Source* EUFGIS - November 2019).





ANNEX 4. Dynamic conservation of non-native populations of forest tree genetic resources

TABLE 5. *Source* EUFGIS - November 2019.

Testing Countries	Number of non-native species occurring	Number of non-native species conserved	**Number of dynamic conserved population of non-native species**
Denmark	19	2	3
Estonia	4	0	0
Finland	30	0	0
France	28	0	0
Iceland	12	0	0
Italy	14	3	6
Norway	8	0	0
Poland	28	6	79
Slovenia	16	0	0
Spain	15	0	0

ANNEX 5. Potential for the production of Forest Reproductive Material

TABLE 6. *Source* FOREMATIS when applicable - November 2019.

Testing Countries	Total number of FRM production units (for all 4 categories combined)	Total number of species for which there is at least 1 FRM production unit
Denmark	314	35
Estonia	175	11
Finland	351	13
France	1,656	55
Iceland	*NA*	*NA*
Italy	897	36
Norway	67	19
Poland	29,141	38
Slovenia	238	38
Spain	8,328	58

NA: not available

EUFORGEN