MaP-FGR

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Policy Brief



Marginal and peripheral forests:
a key genetic resource for enhancing the resilience of European forests to global change

Global environmental change, and particularly climate change, challenges the persistence and sustainability of European forests. Changes in climate may trigger shifts in species ranges and have direct impacts on tree survival, growth and reproduction. The potential for forests to adapt to environmental change depends fundamentally on genetic resources, but this potential is being threatened by a diverse set of pressures including human population growth, forest fragmentation and neglect. Future management strategies must aim to conserve genetic variation, secure and enhance the adaptive potential of populations, and deploy forest reproductive material resistant to future environmental stresses.

Marginal and peripheral tree populations **(MaP)** constitute valuable forest genetic resources **(FGR)** for enhancing the resilience of European forests. This is due to their specific adaptations, which are the outcome of evolutionary processes operating over long periods of time in marginal environments. However, at the same time, MaP FGRs are uniquely vulnerable and in urgent need of conservation.

Existing policies recommend sustainable forest management at all scales in order to ensure forest regeneration. Moreover, they stress the need to maintain forest multi-functionality and the delivery of multiple goods and services (ecosystem functioning, timber production, biomass, social and cultural goods and services, etc.).

In this policy brief we aim to provide specific recommendations for the conservation and use of forest genetic resources of marginal and peripheral populations of trees.

Main issue: MaP populations are likely to have developed specific genetic variants and genetic resources found nowhere else. These unique genetic resources could be used to help European forests adapt to the challenges of the 21st century. MaP populations should therefore be of the highest conservation priority.

Marginal and Peripheral forest tree populations grow at the ecological, altitudinal or geographical edges of a species distribution

Context

MaP FGR are a key priority of the Global Plan of Action for Forest Genetic Resources

The FAO Global Plan of Action for the conservation, sustainable use and development of FGR defines its Strategic Priority 7 as "support assessment, management and conservation of marginal and/or range limits forest species populations".

- "Marginal populations should therefore have high priority in global and regional conservation strategies and programmes"
- "Action: Develop guidelines for the inventory and documentation of marginal forest species populations and promote their management and conservation through their integration into conservation networks and by emphasizing the participation of local communities. Support programme development at global and regional levels to assess marginal populations and promote their conservation and evaluation in both *in situ* and *ex situ* conditions".

Problems to be addressed for management of resilient European forests

An EU watchword for forest management in the future is sustainability (New EU Forest strategy, COM(2013)659), which implies ecosystem resilience.

KEY ISSUES

✓ **Ensure the potential and multifunctionality of forest through systematic sustainable forest management**

✓ **Protect forests and biodiversity from the effects from extreme events (*e.g.* fires, storms, heatwaves), water scarcity, pests: promote actions minimising forest vulnerability to climate change**

GUIDELINES

- Need for general investment to enhance resilience, filling objectives for biodiversity conservation, adapting to climate change, protecting forests, etc.
- Enhance resilience and adaptation capacities based on EU strategy on adaptation to climate change COM (2013)216, particularly fulfilling actions 2 and 4
- Fill knowledge gaps, strengthen research, encourage further development of EU database of forest reproductive material and species/genetic diversity distribution maps
- Prioritise and streamline adaptation actions in forest policies
- Enhance conservation of forest genetic resources in species and populations

Key points

MaP FGR are key resources for the resilience of European forests to climate change

- MaP FGR importance is already widely recognized, yet efforts on their identification, characterization, management and conservation need to be significantly improved and developed
- MaP populations have unique genetic and ecological properties that make them valuable for the future of European forests and forestry…
- … at the same time MaP populations, particularly those at the rear edge or low elevation ecological margins, are uniquely vulnerable.

KEY RECOMMENDATIONS

✓ **Establish a plan for adaptive conservation of marginal and peripheral populations (MaP) and genetic resources**

✓ **Consider MaP populations as resources for dealing with adaptation to climate change**

✓ **Strengthen research and education (particularly in professional schools) on genetic resources and adaptive processes**

Current policy processes that already highlight and recognize the importance of MaP FGR

- Adaptation to climate change and conservation of genetic resources are objectives of the EU Forest Strategy: genetic diversity and forest tree species diversity should be maintained and protected in order to ensure forest resilience
- The importance of forest genetic diversity is recognized by UN and CBD decisions: within species and within population diversity is important for biodiversity and sustainable use and should be taken into consideration in forest management
- The State of the World's Forest Genetic Resources report (FAO) recognizes that "Marginal and/or range-limit populations may be vital for tree species' adaptation to the novel environmental extremes […]".

What the COST Action has already achieved

- Brought together scientists and stakeholders from 30 European countries and associated countries to raise awareness of the need to conserve and sustainably use the genetic resources of MaP populations
- Established a series of databases on MaP populations in Europe
- Trained more than 50 students and early career scientists on key issues in theory and practice on MaP FGR
- Funded over 25 early stage researchers for pursuing their research projects on Map FGR in partner country laboratories.

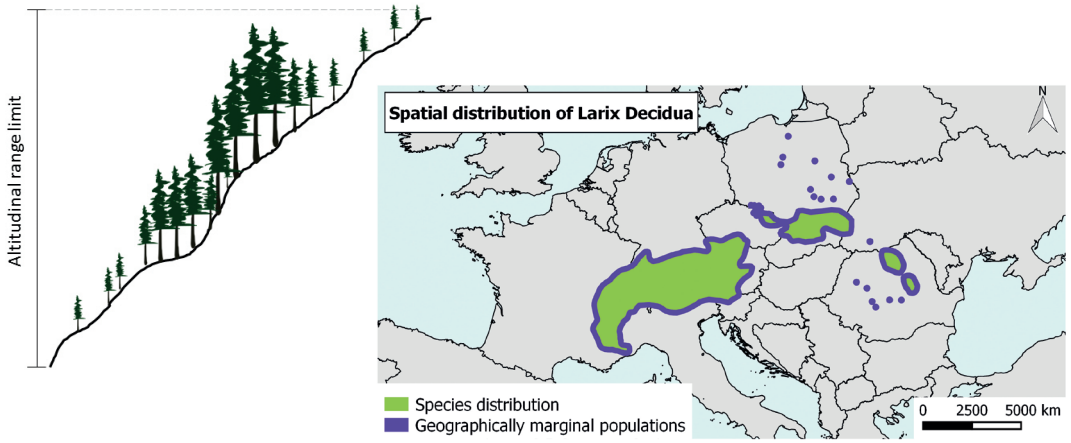
For more information:

http://map-fgr.entecra.it/, http://www.cost.eu/

Two types of marginality: geographic and ecological

Geographically marginal/peripheral populations are at the edges of a species geographic range, furthest away from the geographic core. Leading edge populations are at the expanding geographic edge of the distribution range whilst rear edge populations are undergoing retreat.

Ecologically marginal populations are those furthest from the most common ecological conditions of the species (the realized ecological niche).



Source: map based on EUFORGEN database of natural distribution of Larix decidua (2009, www.euforgen.com)
Source: figure completed by the authors, inspired by Ettinger et al., 2011.

MaP populations need to be better identified, characterized, managed and conserved in Europe

✓ Need for better identification

The environmental and ecological factors determining species ranges and limits must be identified, and current and future distributions must be modelled based on the predictions of different climate change scenarios. Yet we are limited by current model capabilities (*e.g. in situ* adaptation is not accounted for), uncertainty in climate predictions, lack of accurate distribution maps for all species, and data with which to determine ecological marginality.

✓ Need for better characterization

We need to identify the highest priority species for adaptation, to collate available FGR in a database, and to characterize the genetic basis of adaptive traits. However, determining which adaptations are most relevant to climate change adaptation is limited by the complexity of interactions, superimposition of natural dynamics and human activities, and by current technical limits (statistics and bioinformatics). Substantial improvement will come from the application of new developments in genomics and by approaching genetic characterization at a European scale.

✓ Need for better management

The risks and impacts of different scenarios on FGR must be identified, as well as priority populations and conservation actions and areas. Indicators for FGR monitoring and technical management guidelines must be developed. Exchanges and communication between specialists and stakeholders should be promoted. These are currently limited by our lack of understanding of the interactions between species, the need for management guidelines tailored to each species and its peculiarities, uncertainty in climate predictions, and the gap in knowledge of long-term adaptive response of populations.

✓ Need for better conservation

A better regulatory framework for MaP population conservation should be developed. However, a plausible legal status for MaP population protection must be identified first.

Specificities of MaP populations

Specificities of MaP populations

- MaP populations are located at the ecological and geographical edges of a species distribution, which makes them more vulnerable to changes of climatic conditions and exposes them to higher pressure
- At the ecological margins, environmental fluctuations are usually more extreme than at the core of the distribution
- MaP populations can be considered as natural laboratories to study processes of genetic adaptation to extreme environmental conditions.

MaP populations may exhibit specific adaptations

- Adaptive traits in MaP populations can differ from those of core populations because their genetic resources have undergone specific selection for extreme environmental factors
- MaP populations may show a particular capability for phenotypic plasticity
- But not all MaP populations are well adapted to local conditions: other factors, such as genetic drift due to small population size or extensive gene flow from populations non adapted to marginal conditions, may prevent local adaptation.

Unique genetic information may be found in MaP populations

- Because of their distinctive evolutionary histories, MaP populations often contain unique genetic variants
- Because of the extreme conditions of the environments they occupy, MaP populations may harbor genes specific for these extreme conditions unlikely to be found in core populations
- MaP populations can be hotspots of biodiversity and may contain particular phenotypic and genetic forms.

MaP populations are living seed banks

- MaP populations are potentially pre-adapted to particular environmental situations and may be useful as seed sources
- MaP populations must be preserved in order to secure their unique gene pools.

INTERESTS AND CHARACTERISTICS OF MAP POPULATIONS

- Possess genetic potential for adaptation
- Contribute to establishment of new populations
- Ensure physical protection for the core population
- Often harbor keystone species of trees of interest for habitat conservation
- Retain evolutionary potential and could develop new adaptive traits

RISKS AND ISSUES:

- High extinction risk because of marginality and small effective population sizes
- Dispersion and regeneration issues on geographic edges (*e.g.*: possible lower density and lower availability of pollen, higher probability of inbreeding, poor soil, etc.). Rate of environmental change may be higher than the evolutionary rate of a species/population, leading to population shrinkage or breakdown

Key recommendations for decision-makers

✓ Adapt management and silvicultural systems for MaP population conservation:

- MaP populations are at high extinction risk: protect and conserve them. Options include: *in situ* conservation (best option which preserves the original gene pool), *ex situ* conservation (complementary when the species range reaches a physical limit), assisted migration
- Reconcile conservation and productive silviculture in MaP populations, to ensure their persistence and sustainability. Endorse evolution-oriented forestry by considering assisted migration options (investigating its feasibility, risks, acceptability and potential) and preserve genetic diversity as a main source of adaptability to unknown future changes (take care of keystone species and declining species).

✓ Set up genetic conservation planning

- MaP populations should be recognised as a valuable source of genes for adaptation to changing climatic conditions, even if the populations themselves may appear to be of low value from a silvicultural or production point of view.

✓ Set up a framework to address the legal issues on the deployment of new forest reproductive material

✓ Strengthen research and education and reinforce the information flow between researchers, managers and policy makers

✓ Stimulate communication and collaborations

Assisted migration: a controversial option for forest adaptation

Assisted migration is a process of artificial intervention to strengthen the capacity of species to adapt to rapidly changing environmental conditions. In some areas (particularly plains), the velocity of climate change may outpace both the migration and genetic adaptation capacities of populations. Assisted migration would transfer populations, either to safeguard them because they are endangered *in situ* or to use their resources to strengthen the adaptive potential of other populations (assisted gene flow). Assisted migration may consist of the expansion of a distribution range, or short or long-distance displacement. However, such actions involve similar risks to the introduction of any new species, with the added potential of harm to existing populations of the species in the introduction area. For example, the introduction of new ecotypes of an already-present species may favour the more adapted subspecies. Furthermore, the success of artificial migration is not certain: tree species are locally adapted to many components of an ecosystem, particularly the soil composition and interspecific symbioses such as with root fungi. The application of assisted migration is still rare (although preliminary experiments are underway in Canada, France and Italy) and further knowledge on its impacts and consequences are needed before this new process can be integrated in forest strategies and policies. Finally, assisted migration remains a very controversial idea and arouses numerous ethical points: it constitutes completely artificial modification of the landscape and goes beyond what nature should normally be capable of achieving. The social and economic consequences of assisted migration would have to be very carefully studied and tackled before it could be widely implemented.