GenRes Bridge

Genetic resources for a food-secure and forested Europe

ECP/GR EUFORGEN ERFP

Lessons learned from case studies

HOTSPOTS OF GENETIC RESOURCES FOR ANIMALS, PLANTS AND FORESTS

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The European Cooperative Programme for Plant Genetic Resources (ECPGR – www.ecpgr.cgiar.org) is a collaborative programme among most European countries aimed at contributing to rationally and effectively conserve *ex situ* and *in situ* Plant Genetic Resources for Food and Agriculture, and provide access and increase sustainable use. The Programme, which is entirely financed by the member countries, is overseen by a Steering Committee composed of National Coordinators nominated by the participating countries. The Coordinating Secretariat is hosted by The Alliance of Bioversity International and CIAT.

The European Regional Focal Point for Animal Genetic Resources (ERFP – www.animalgeneticresources.net) is the regional platform to support the *in situ* (on-farm) and *ex situ* conservation and sustainable use of animal genetic resources (AnGR) and to facilitate the implementation of FAO's Global Plan of Action for AnGR. Since 2001, ERFP has facilitated collaboration, coordination of work, and exchange of information and experience between different European countries and governmental and non-governmental organizations.

The European Forest Genetic Resources Programme (EUFORGEN – www.euforgen.org) is an instrument based on international cooperation which promotes the conservation and appropriate use of forest genetic resources in Europe. It was established in 1994 to implement Forest Europe Resolution S2. EUFORGEN contributes to the implementation of regional-level strategic priorities of the FAO's Global Plan of Action for the Conservation, Sustainable Use and Development of Forest Genetic Resources.

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1.

THREE DOMAINS: ONE LANDSCAPE!

Genetic resources of forest trees (FGR), agricultural plants (PGR) and livestock breeds (AnGR) are crucial to ensuring food security and for maintaining ecosystems services indispensable for human and other species' lives and wellbeing. Beside covering present human needs, genetic resources are also the reservoir of options for future use of biological resources and ecosystem resilience. Thus, by losing genetic resources we put the future of the biodiversity and our society at risk.

Although domestication processes tend to narrow down genetic diversity, it was not until the 20th century that significant loss of genetic resources (GR) began to occur. Such losses are mostly due to general agricultural intensification coupled with abandonment of traditional breeds and varieties. For example, the abandonment of semi-natural grasslands drastically affects the biodiversity associated with these environments and the diversity in livestock farming. Intensified production has relied on the use of agrochemicals, aimed at high productivity, and has prioritised produce uniformity over diversity. Furthermore, heavy farm machinery used in intensified production has led to soil structure degradation and a loss of organic matter, decreasing soil fertility and health. The decline in agricultural genetic resources diversity has been highlighted since the early 1960s. For European forest tree species, most concern is associated with reduced population sizes following environmental changes, such as drought and invasive alien pests and pathogens. Consequently, significant investments have been made in conservation and sustainable management efforts in all GR domains (forest, plant, and animal), such as the establishment of genebanks, cryopreservation, development of sustainable breeding programmes, and various *in situ* and on-farm conservation initiatives. However, this has taken place primarily within domains, focusing on breeds, varieties and species rather than developing inter-domain strategies to protect and maintain genetic resources, particularly in the *in situ* context.

Within the EC Horizon 2020-funded project GenRes Bridge, we are developing new approaches to conserve and sustainably manage genetic resources, not only at the species, variety or breed level, but also at the landscape level. Emerging evidence suggests there may be linkages between genetic diversity hotspots of AnGR and PGR, and between these two and FGR genetic diversity. It may therefore be possible to identify 'Landscape-based Genetic Diversity Centres'; genetic hotspots where cost-effective conservation and management of genetic resources might be more efficiently implemented. This is timely considering the EU's target of reserving at least 10% of agricultural area under high diversity landscape features (EU Farm to Fork) and 30% of the EU's land areas legally protected (EU Biodiversity strategy).

A landscape-based approach to the conservation and sustainable use of genetic resources across domains is still novel. Here, we share our efforts to (a) identify and delimit European domain-specific genetic diversity hotspots, (b) characterise genetically diverse landscapes (demonstration cases), and finally (c) discuss our concept for integrated management and conservation of the genetic resources across domains. To achieve the project's objectives, we selected five genetically diverse landscapes across Europe and beyond to showcase potential issues of management, inter-domain dependencies, and the interaction of these domains with the wider biodiversity.

2.

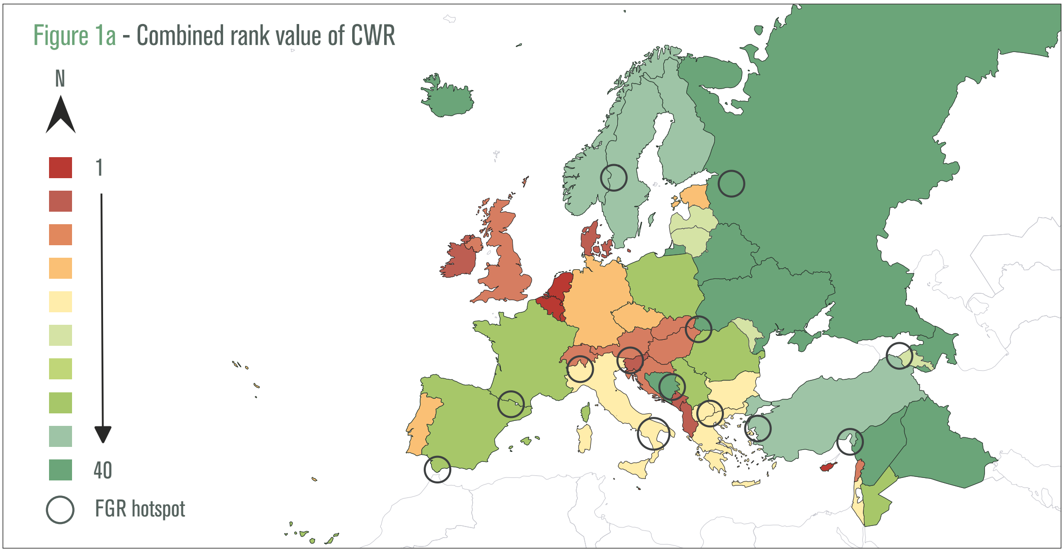
A EURO-CENTRIC PERSPECTIVE ON CENTRES OF GENETIC RESOURCES AND DOMESTICATION

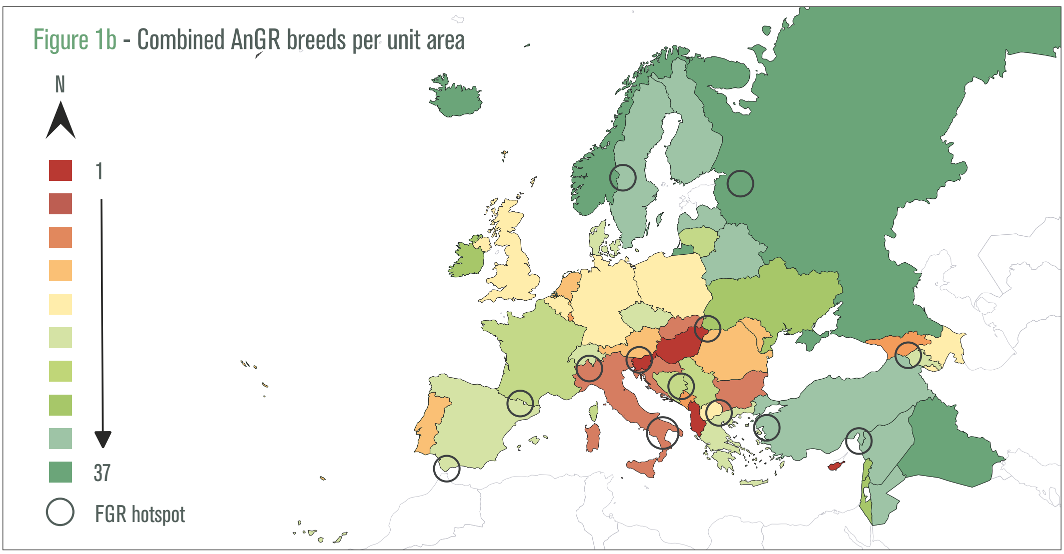
Mediterranean Europe and the Near East are global hotspots of biodiversity. The variability in climate, topography and anthropogenic impacts have contributed to the high species diversity in the region. The Fertile Crescent has also been a crossroads for species migration between Africa and Eurasia – boosting biodiversity – and it is a major domestication centre for crop species and varieties, and for livestock breeds. Finally, the glacial refugia of southern Europe and their diverse geomorphology have contributed to Europe's extensive and unique forest genetic diversity.

As part of the project, we attempted to identify hotspots of diversity for each genetic resource domain by means of available data i.e., those areas with high numbers of different taxa and/or those areas with high levels of genetic diversity. The identification of hotspots of diversity was approached differently for each domain, due to the differing availability and format of distribution data and expert knowledge of species distributions:

→ **PLANT DOMAIN**

For plant genetic resources (PGR), distribution data was collected and mapped using Geographic Information System (GIS) approaches for crop wild relatives (CWR) and landrace taxa separately. Data was gathered from the Farmer's Pride H2020 project, the European Search Catalogue for Plant Genetic Resources (EURISCO) and Genesys. Extra data was gathered from St Joseph University, Lebanon, for Lebanon, Syria, Turkey, Jordan and Iraq and from the University of Birmingham for the same countries plus Cyprus, Portugal and Italy. The total presence points used for CWR in this study was 3,114,175 representing locations for 1,107 taxa; and for landraces (LR), 172,212 presence points were obtained representing 1,549 taxa. The total number of CWR and LR within each country per unit area was calculated.





Map indicating the combined richness of CWR and AnGR breeds at national level and the important areas of FGR diversity (Fig. 1a). Map illustrating the combined richness of landraces and local AnGR breeds (Fig. 1b). The richness of CWR, LR and AnGR (total breeds and local breeds) is based upon the number of taxa per unit area of that country. These values were then ranked against each other to allow comparison between different countries. Rank values closer to 1 (in red colours) have highest taxa richness. Approximate locations of high diversity areas for FGR are shown in black circles and represent a mixture of areas harbouring main glacial refugia and areas where colonisation routes met during the recolonization process. For FGR, species richness is not considered, i.e. important areas of FGR diversity are located also in areas with lower tree species richness such as Northern Europe. It is possible that not all distribution data was available for all countries within the regional databases (see main text for further discussion).

→ ANIMAL DOMAIN

AnGR distribution data was gathered from the FAO Domestic Animal Diversity Information System (DAD-IS). There was a total of 2,031 breeds identified in the reported data. The total number of animal breeds per unit area and the number of local animal breeds (as classified according to FAO) per unit area within each country was calculated.

→ FOREST DOMAIN

Due to the important role that glacial refugia played in the distribution of forest genetic diversity across Europe, glacial refugia, colonisation routes and genetic diversity information was used for identifying important areas of forest genetic resources (FGR) richness. The location of the glacial refugia and colonization routes presented earlier (Figure 1) were reconstructed based on a literature review.

Our data resulted in two comparisons to identify potential hotspots of genetic resources. Figure 1a illustrates CWR, total AnGR breeds and FGR hotspots, with the eastern alpine countries and Adriatic countries showing high taxa richness in CWR and AnGR breeds as well as containing FGR hotspots. Figure 1b illustrates LR, local AnGR breeds and FGR hotspots, with notable taxa richness across all domains in the eastern Alpine and Adriatic countries, as well as in Italy and Hungary. However, our analyses also clearly illustrate the **differences in data availability across the region and within each domain.**

The data collected at regional level for the different domains was available at different spatial scales, making it challenging to compare taxa distribution across the region and to identify areas of high genetic diversity. At the regional level, distribution data across PGR, AnGR and FGR are collected in different ways, for example CWR and LR data is collected at the coordinate level and domesticated animal distribution is documented as presence within a country.

To conduct an accurate and reliable comparison across genetic resource domains it is necessary to have **standard procedures in collecting distribution data.** Further development of **genetic diversity indicators** (or proxies) is needed to estimate multi-domain genetic diversity at the landscape level. The bridging of these knowledge gaps will allow the identification of important areas for genetic resource conservation, facilitating on-the-ground implementation of conservation and management practices in genetically diverse landscapes. Such indicators are needed, as Europe and the near East are not equipped with sufficient data on genetic diversity distribution of PGR, AnGR and FGR to adequately assist conservation.

Figure 2: The demonstration cases in Norway (Aurland)
Alps (Mont Ventoux in France, Dolomites in Italy, Triglav National Park in Slovenia)
and Lebanon (Ehden/Qadisha valley).

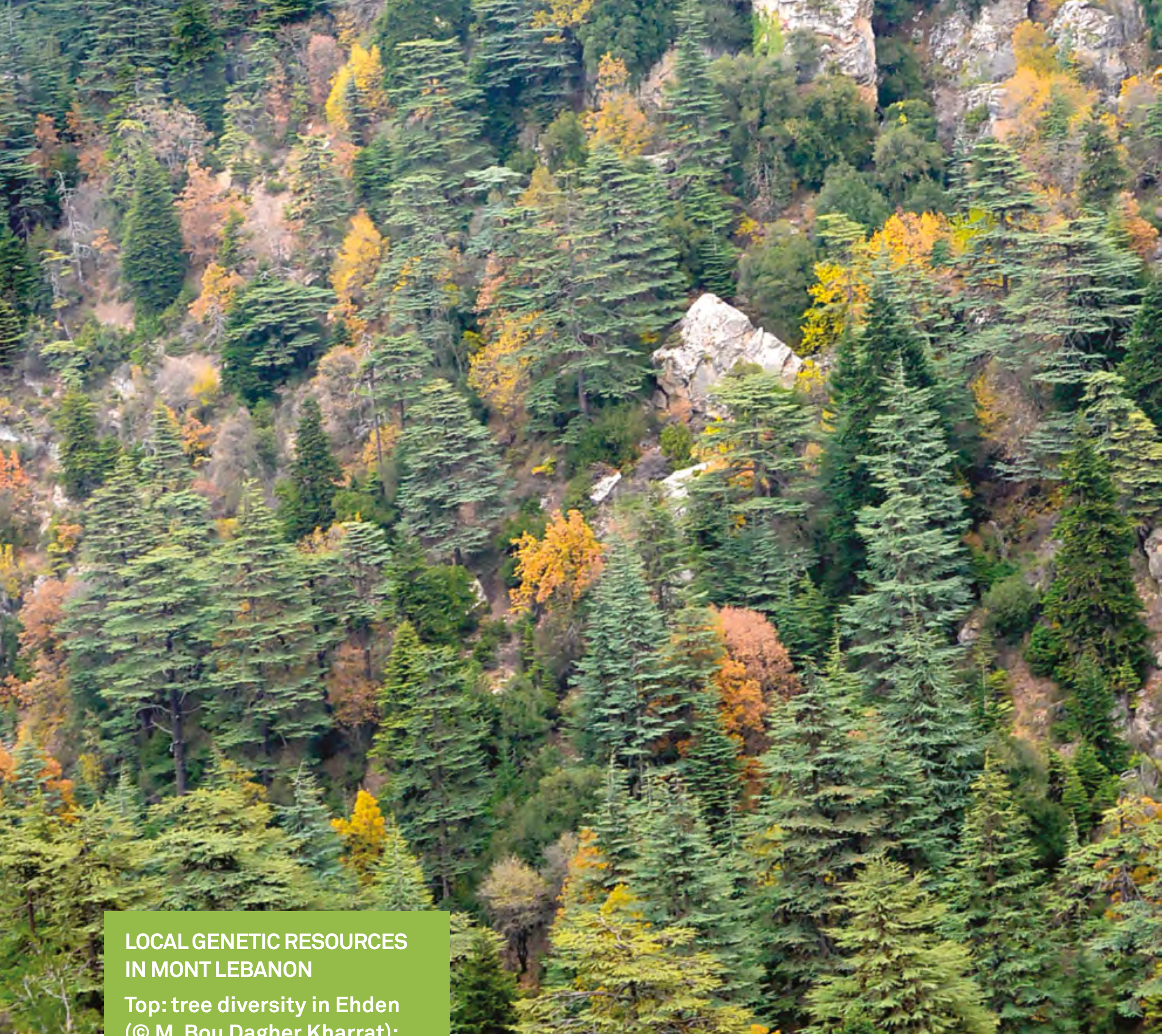
Location of demonstration cases

3.

FIVE LANDSCAPES RICH IN GENETIC RESOURCES

The five landscapes selected as demonstration cases are located across Europe and in the Middle East – from Aurland in Norway and across the Alps (Mont Ventoux in Alpine France, the Dolomites in Alpine Italy and Triglav National Park in Alpine Slovenia) to Ehden / Qadisha Valley on Mt Lebanon in Lebanon (Fig. 2). Lebanon, being part of the Fertile Crescent, is one of the world's most important domestication centres, as nearly all crop and farm animal diversity in Europe originated there. A commonality of the five demonstration cases is the affiliation to UNESCO, either as Man and Biosphere Reserve sites (MAB) (Mont Ventoux, France and Triglav National Park, Slovenia) or as World Heritage sites (all remaining demonstration cases), which combine particular landscape features and cultural heritage with strong ties to agriculture and genetic resources diversity.

The demonstration cases are characterised by supporting mixed production systems that make use of plants, animals and forests, and a variable and complex topography including highly-productive lowland areas and mountain grasslands. They also have in common agro-eco-touristic potential and distinct regional identity. These characteristics have allowed the development of innovations based on genetic resources. Therefore, genetic resource diversity is not only "old stuff from the past" but rather a great source of added value. Genetically-diverse landscapes exist where high levels of genetic diversity in different domains overlap. We believe that conservation could be more efficiently implemented in these landscapes, as management interventions may benefit several domains.



LOCAL GENETIC RESOURCES IN MONT LEBANON

Top: tree diversity in Ehden (© M. Bou Dagher Kharrat); bottom: goat breed 'Chami' (© S. Marcos). Right page: local wild grains (© M. Bou Dagher Kharrat).

1 LEBANON CASE

Qadisha valley, the Forest of the Cedars of God and Horsh Ehden Nature Reserve

Situated in Bcharre District, Governorate of North Lebanon in the Eastern Mediterranean area, the territory lays at the foot of the highest peak in Mount-Lebanon reaching an altitude of 3,084 m. It features geological, climatic and human factors that have shaped genetic resources in this 'cradle of civilization' where plant and animal domestication commenced.

KEY MESSAGES

→ The genetic resources diversity of the Fertile Crescent is the **raw material for agriculture** and brought humans in this region to sedentary lifestyle about 10,000 BP.

→ CWR are abundant in the area, and a **critical source of genetic diversity** for cultivated plants. Forests should be kept open by means of sustainable grazing to maintain CWRs.

→ Production systems should be **diversified** to exploit the genetic resources reservoir of the area. The genetic resources belong to the cultural heritage and provide opportunities for local development and promoting local identity.

LOCAL GENETIC RESOURCES IN MONT-VENTOUX

This page: Atlas cedar selected seed source 'Ventoux' (© INRAE UEFM). Right page: (left) local sheep breed 'Mourerous' (© CORAM – F. Berthet) and (right) small spelt variety 'Sault de Vaucluse' (© regional natural Park Mont- Ventoux).

2 FRENCH CASE

The Regional Natural Park Mont-Ventoux

Located in the South-Western range of the French Alps, the territory is characterized by diverse ecological conditions from alpine to Mediterranean climate, and land use structured along altitudinal and longitudinal gradients. It is rich in local crop, animal and forest genetic resources.

KEY MESSAGES

→ Genetic resources provide **multiple ecosystem services** and interact with the wild biodiversity, demonstrating the unique cohesion of these genetic resources with agricultural and ecological diversity, and the society they sustain.

→ Through their diversity, genetic resources are a **key factor for resilience** of the local agro-systems facing global change, therefore contributing to a number of Sustainable Development Goals.

→ These genetic resources are **continuously evolving**, dynamically driven by the interplay of human interventions and natural processes, and thus constitute a living heritage.

LOCAL GENETIC RESOURCES IN PANEVEGGIO PALE SAN MARTINO PARK

This page: Norway spruce forest (© S. Raniolo). Right page: Alpine gray cows grazing on summer farm (www.stradadeiformaggi.it) and highlands pastures and meadows as examples of High Nature Value Farmland (© S. Raniolo).

3 ITALIAN CASE

The Dolomites

Paneveggio Pale San Martino Park is part of the Dolomites, eastern Alps. It is characterized by the Dolomite peaks and rural landscapes formed by local communities, such as fields and meadows dotted with traditional huts and buildings, pasturelands with typical stables, and forests whose management is renowned for producing high quality wood for violins.

KEY MESSAGES

- → **Humans** play a critical role in conservation and sustainable use of genetic resources. In this geographical area, the agri-food sector is characterized by a strong cooperative structure, contributing to sustainable rural development and to other economic activities like eco-tourism.

- → The **agro-ecological practices** are strongly linked with genetic resources conservation and valorisation, but also with habitat and landscape conservation.

- → Agriculture (crop and livestock) and forest conservation **practices interact** to maintain habitat biodiversity.

LOCAL GENETIC RESOURCES IN TRIGLAV NATIONAL PARK

This page: overview of the Pokljuka plateau with Triglav (© Peter Čadež & Robert Klančar). Right page: Cika cattle (© Mojca Simčič) and diversity of maize kernels (© Stegnar Kalan).

4 SLOVENIAN CASE
Triglav National Park

Triglav National Park (TNP), in the Eastern Julian Alps, harbours the entire gradient from the warm sub-Mediterranean climate to cold alpine environments. Strong interdependence exists between local breeds, crop and forest genetic resources which provide a range of ecosystem services. The management of the genetic resources allows conservation of specific breeds and plant varieties, helps to maintain the landscape mosaic, and supports natural (non-agricultural) diversity of species and habitats.

KEY MESSAGES

- → **Traditional management** practices have shaped the genetic resources which represent a natural and cultural heritage and provide support for wider biodiversity.

- → Support of **infrastructure and services** (such as: product-labelling systems, support to niche markets, different incentives, support for highly-localized cultural heritage and farm-tourism) for owners and managers of genetic resources in remote and challenging environments is essential.

- → **Research** on genetic resources and their conservation needs to be more multidisciplinary, more participatory and more focused on interactions between different domains, supporting their conservation and roles in natural and cultural heritage.

LOCAL GENETIC RESOURCES IN AURLAND

This page: Undredal village hosting two goat farms. Right page, (left) local goat breed - Norwegian Dairy Goat and (right) the agricultural College (© Eline Myking).

5 NORWEGIAN CASE
Aurland

Aurland is the northernmost demonstration-case located in interior Sognefjorden, western Norway. The municipality ranges from sea-level to mountains up to 1,809 masl, and covers fertile valley bottoms and extended mountain pastures. Aurland also hosts an agricultural college and exemplifies how the human factor dynamically interacts with the environment to support genetic resources diversity.

KEY MESSAGES

→ **Scandinavian landscapes can support exceptional genetic diversity** due to the long growing season enabled by the Gulf Stream and the long days of northern summers.

→ **Interdependencies** between genetic resources of forest trees (e.g. shelter/protection, pollination, firewood, forage for goats and sheep), farm animals (landscape maintenance and openness, manure) and plants (pollination) and in turn with the wider biodiversity - are numerous and probably undervalued.

→ Development of complete and locally-based **value chains** (cheese, butter, sausages) from production to refinement and sale has been successful.

→ **Branding** of high-quality local produce from iconic landscapes offers opportunities for extensive farming and diversity maintenance of the genetic resources in use. The possibilities of connecting the genetic resources closer to the branded produce should be explored.

Genetically-diverse landscapes may add value to local communities in terms of agri-tourism and certified food production, by harnessing their aesthetic and recreation potential, local genetic resources and associated stakeholder engagement.

4.

GENETICALLY-DIVERSE LANDSCAPES
A CONCEPT OF INTEGRATED CONSERVATION OF GENETIC RESOURCES

Genetically-diverse landscapes can be defined as landscapes which host exceptionally high-levels of genetic diversity for AnGR, PGR, and FGR - and the wider biodiversity sustained by these domains. This is due to their natural conditions and historical management regimes. However, landscape managers and other stakeholders need to understand what is needed for their maintenance and development, and what are the characteristics of these landscapes.

Here we propose a concept of integrated conservation and sustainable use of genetic resources across plant, animal and forest domains, embedded in the joint political and legal frameworks of agriculture and forestry along specific landscape features and according to their management strategies. Thus, such a concept will need to **combine a top-down approach** (EU and national/regional level legislation and initiatives)**, with a bottom-up approach** where multiple local stakeholders are the key drivers of on-the-ground conservation. Cross-domain stakeholders (farmers, forest owners, managers, and local/ regional decision-makers, conservation biologists) should be identified to legitimize the process and promote knowledge transfer and engagement.

Ideally, the group of local stakeholders should set realistic and **sustainable management goals** for PGR, AnGR and FGR, and develop an **area management plan** with emphasis on production systems, conservation and sustainable use. Management plans should embrace the relevant genetic resources within the target landscape, including the wider biodiversity. A set of simple indicators (or proxies) for genetic diversity should be developed to monitor landscapes at relevant intervals, in parallel with monitoring the agricultural production. Interdependencies between domains, such as pollination of crops, and links to wider biodiversity and ecosystem services should be explored as public-good components across domains.

Our review suggests that *genetically-diverse landscapes* are often associated with **heterogeneous landscapes,** and that these landscapes host higher genetic resources diversity in all domains as well as supporting wider biodiversity, than more homogeneous landscapes. Simply, varied topography translates into a diversity of environments of importance for wider biodiversity, as well as options for complete three-domain agricultural production systems within definite landscapes, which make use of both highly productive lowland areas and marginal mountain pastures in a continuum. It is therefore not surprising that all demonstration cases elaborated above come from heterogeneous landscapes. Targeting heterogeneous landscapes in conservation allows an extensive cross-domain genetic diversity within a given geographic entity.

Genetically-diverse landscapes may **add value to local communities** in terms of agri-tourism and certified food production, by harnessing their aesthetic and recreation potential, local genetic resources and associated stakeholder engagement. This potential is probably underutilised as local food supply chains have flourished in recent years both in the EU and USA.

Taken together, we suggest a **novel concept** of integrating conservation and sustainable use by putting genetically-diverse landscapes at the forefront, backed up by management plans, and anchored in overarching policy and legal frameworks, and through local stakeholder initiatives. We believe that such landscapes, in many cases with distinct regional identity, have a great potential for geographical-origin branding and making links between the local genetic resources, the landscape and the produce.

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