



Tree and forest biological diversity : a treasure chest of European global wealth, well-being, resilience and leadership for the future

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Forest genetic resources and ecosystem services under present and future scenarios: an explorative expert-based study in Europe

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<https://optforests.eu>



Outline

- I. Rationale and objectives
- II. Methodological approach
- III. Main results
- IV. Next steps
- V. Final considerations



2

Rationale and objectives

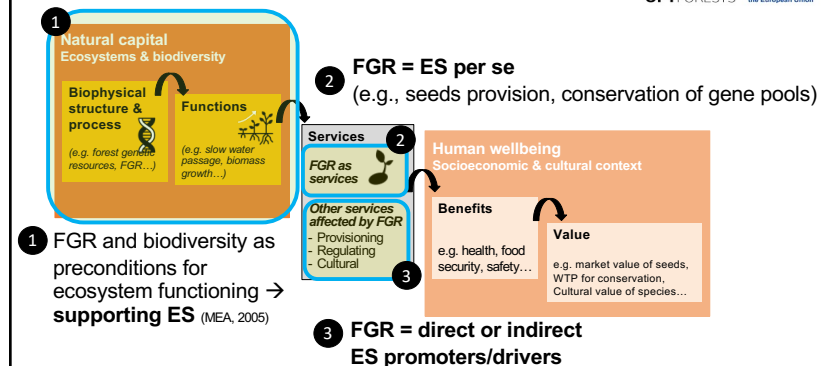


General objective

Identify and estimate the **ecosystem services (ES)** associated to **forest genetic resources (FGR)**, their expected **changes** and the **risks** associated with the new FGR uses in **six European Union (EU) countries** (Italy, France, Slovenia, Romania, Finland and Denmark) and at **EU level**

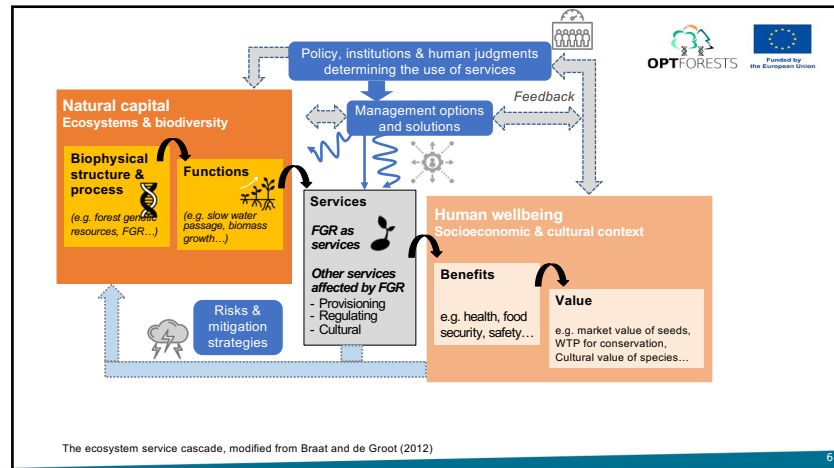
3

Multifaceted nature of the FGR-ES link



The ecosystem service cascade, modified from Braat and de Groot (2012)

5



Specific objectives (SO)

SO1. To identify and analyze a list of **FGR management practices** along with associated **forest reproductive materials (FRM)** that can contribute improving ES supply in six EU countries (IT, FI, FR, SI, RO, DK) and at the EU scale

SO2. To assess **ES supply** associated with different **FGR management practices**

SO3. To investigate how different **narratives about the future human-nature relationships** associated with different mitigation and adaptation strategies to future climatic conditions could **influence the adoption of FGR management practices** and the **delivery of ES**

SO4. To evaluate the **environmental, socio-political, and economic-technological risks** associated with the potential introduction of specific FGR management practices, as well to identify possible mitigation strategies to address these risks

Delphi method

- Iterative survey-designed, expert-based & anonymous method with controlled feedback
- To collect experts' opinions on a particular issue and identify/explore areas of consensus or disagreement



Expert panel (n=67)

- Geneticists
- Ecologists
- Socioecologists
- Economists
- Decision-makers

Country & EU-wide expertise and experience

Identification based on:

- Project partners (PP)' inputs
- Additional search (Scopus, WoS, international networks...) and snowball sampling

Survey testing & refining

Preliminary test @UNIPD

Pilot test with OptFORESTS PPs

Full Survey

Survey: structure



0. **Introduction** (privacy & data handling, objectives, structure and key definitions)
1. Selection of 3 **FGR management practices** with the greatest positive impact on the supply of ES (@country & EU scale) + identification of the most appropriate level of **genetic diversity management**, and associated **FRM**

Each round consisted of three separate blocks:

1. Provisioning ES
2. Regulating ES
3. Cultural ES

13

FGR management (mgmt) practices

1. Novel low-input breeding strategies (NL-IBS)
2. High intensity breeding (HIB)
3. Seed/Gene banks (Ex-situ conservation) (SGB)
4. Conservation seed orchards/clonal archives (CSO/CA)
5. Selected seed stands (SSS)
6. Silviculture of genetically mixed stands (SGMS)
7. Selective thinning (ST)
8. Rescue of declining forests (RDF)
9. Forest restoration (devastated areas) (RDS)
10. Landscape-scale genetic heterogeneity patterns (LSGHM)
11. (...)

Level of genetic diversity mgmt

- Genes
- Individual tree
- Population
- Species
- Mix

FRM

- Seeds
- Cuttings
- Lab-based clonal material
- ...
- Mix

14

Survey: structure



0. **Introduction** (privacy & data handling, objectives, structure and key definitions)
1. Selection of 3 **FGR management practices** with the greatest positive impact on the supply of ES (@country + EU scale) + identification of the most appropriate level of **genetic diversity management**, and associated **FRM**
2. Selection of **ES positively impacted** (i.e., increase in ES supply) by selected FGR management practices

15

Ecosystem services

#	Category	ES
P1	Provisioning	Firewood
P2	Provisioning	Food from wild plants
P3	Provisioning	Genetic materials
P4	Provisioning	Game and trophies
P5	Provisioning	Timber
P6	Provisioning	Water quantity
R1	Regulating	Air quality
R2	Regulating	Carbon storage
R3	Regulating	Genetic pool protection
R4	Regulating	Habitat for plants and animals
R5	Regulating	Human health
R6	Regulating	Natural hazard protection
R7	Regulating	Noise reduction
R8	Regulating	Soil quality
R9	Regulating	Temperature reduction
R10	Regulating	Water quality
C1	Cultural	Aesthetics
C2	Cultural	Education and research
C3	Cultural	Outdoor recreational/sport activities
C4	Cultural	Mushroom and other wild product picking
C5	Cultural	Hunting
C6	Cultural	Spiritual value
C7	Cultural	Traditional/local culture/knowledge

- Provisioning ES (6)
- Regulating ES (10)
- Cultural ES (7)

Source: Adapted from Roitsch *et al.* (2022) as referenced in Winkel *et al.* (2022)

16

Survey: structure



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2. Selection of **ES positively impacted** (i.e., increase in ES supply) by selected FGR management practices
3. Assessment of **impacts** of selected **FGR management practices/FRM** on **ES** (i.e., increase, decrease, steady) under **future scenarios**

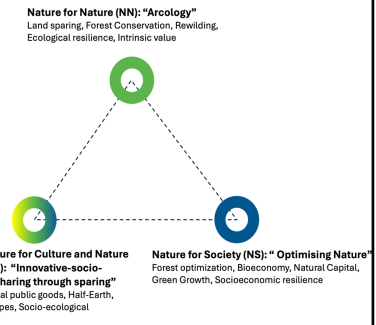
17

Future scenarios



Nature Futures Framework (NFF)
storylines (Paz-Duran *et al.*, 2023) combining
IPCC scenarios on climate change and the
IPBES scenarios on biodiversity loss

3 different pathways considering the
potential for climate change adaptation and
mitigation by 2050



18

Survey: structure



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2. Selection of **ES positively impacted** (i.e., increase in ES supply) by selected FGR management practices
3. Assessment of **impacts** of selected **FGR management practices/FRM** on **ES** (i.e., increase, decrease, steady) under **future scenarios**
4. Investigation of **environmental, socio-political, and economic-technological risks** associated with the adoption of identified FGR management practices, along with proposed **risk-mitigation strategies**
5. **Information about the experts** for analyzing their responses and survey data

19

Experts group	N.	Profile description
Geneticists	4	Scientists or other experts, solid experience (training, teaching, research, professional experience, publications) in forest- and/or tree-related genetics (genetic improvement, breeding, biological diversity) at the national (IT, FR, SI, RO, FI or DK) or broader (i.e., European or beyond) scale.
Ecologists	2	Scientists or other experts, solid experience (training, teaching, research, professional experience, publications) in forest ecology (animal or plant biology, forest dynamics, plant-animal relationships) and ecosystem services (e.g., carbon sequestration, habitat conservation, soil formation and conservation, biodiversity etc.) important at the national (IT, FR, SI, RO, FI or DK) or broader (i.e., European or beyond) scale.
Socioecologists	2	Scientists, economists or other experts, solid experience (training, teaching, research, professional experience, publications) in ecosystem services and their assessment (biophysical and economic assessment, impacts on the local/global society and economy (e.g., timber or non-timber products, human-nature relationship, tourism) at the national (IT, FR, SI, RO, FI or DK) or broader (i.e., European or beyond) scale.
Economists	2	Economists, political scientists or other experts, with solid experience (training, teaching, research, professional experience, publications) in environmental economics with a focus on the assessment of ecosystem services important at the national (IT, FR, SI, RO, FI or DK) or broader (i.e., European or beyond) scale.
Decision-makers	2	Decision- or policy-makers, with solid experience (reputation, professional experience, publications) in environmental policies related to ecosystem services important at the national (IT, FR, SI, RO, FI or DK) or broader (i.e., European or beyond) scale.

22

Results

Respondents

Delphi Process Period	Round 1 12/24 - 03/25		Round 2 04/25 - 07/25		Round 3 08/25 - 10/25	
	Invited	Complete	Invited	Complete	Invited	Complete
Country - Respondents						
Italy	22	17	17	11	11	8
France	16	11	11	4	4	3
Slovenia	8	4	4	4	4	4
Finland	15	10	10	6	6	4
Romania	4	4	4	4	4	4
Denmark	2	1	1	1	1	1
Total	67	47	47	30	30	24

Attrition rate: 30% 36% 20%

Overall response rate: 36%

Italy most represented country (n=8 i.e. 33%)

Geneticists most represented expert group (n=10 i.e. 42%)

23

Results

1. FGR management practices: country level

Most common practices:
Landscape-scale (LSGHM) → 25.9%
Mgmt of mixed stands → 19.5%

A scattered landscape

1. NL-IBS: Novel low-input breeding strategies; 2. HIB: High intensity breeding; 3. SGB: Seed/Gene banks; 4. CSO/CA: Conservation seed orchards/clonal archives; 5. SSS: Selected seed stand; 6. SGMS: Silviculture of genetically mixed stands; 7. ST: Selective thinning; 8. RDF: Rescue of declining forests; 9. RDA: Restoration of devastated areas; 10. LSGHM: Landscape-scale genetic heterogeneity management

Block 1: Provisioning ES											
Country	1. NL-IBS	2. HIB	3. SGB	4. CSO/CA	5. SSS	6. SGMS	7. ST	8. RDF	9. RDA	10. LSGHM	11. other
Denmark	33.3%	0.0%	0.0%	0.0%	0.0%	33.3%	0.0%	0.0%	0.0%	0.0%	0.0%
Finland	20.0%	0.0%	0.0%	0.0%	10.0%	20.0%	0.0%	0.0%	0.0%	40.0%	0.0%
France	0.0%	0.0%	0.0%	22.2%	33.3%	33.3%	11.1%	0.0%	0.0%	0.0%	0.0%
Italy	4.8%	4.8%	9.5%	0.0%	4.8%	9.5%	0.0%	14.3%	23.8%	28.6%	0.0%
Romania	40.0%	0.0%	0.0%	30.0%	0.0%	0.0%	30.0%	0.0%	0.0%	0.0%	0.0%
Slovenia	10.0%	0.0%	0.0%	0.0%	0.0%	40.0%	10.0%	0.0%	30.0%	10.0%	0.0%
EU	11.5%	4.9%	4.9%	6.6%	11.5%	11.5%	3.3%	6.6%	11.5%	24.6%	3.3%
Block 1: Regulating ES											
Country	1. NL-IBS	2. HIB	3. SGB	4. CSO/CA	5. SSS	6. SGMS	7. ST	8. RDF	9. RDA	10. LSGHM	11. other
Denmark	33.3%	0.0%	0.0%	0.0%	33.3%	0.0%	33.3%	0.0%	0.0%	0.0%	0.0%
Finland	20.0%	10.0%	0.0%	0.0%	30.0%	0.0%	0.0%	0.0%	40.0%	0.0%	0.0%
France	0.0%	0.0%	0.0%	12.5%	0.0%	25.0%	0.0%	25.0%	12.5%	12.5%	0.0%
Italy	4.8%	4.8%	4.8%	0.0%	4.8%	9.5%	0.0%	19.0%	28.6%	23.8%	0.0%
Romania	40.0%	0.0%	0.0%	20.0%	0.0%	0.0%	20.0%	0.0%	10.0%	10.0%	0.0%
Slovenia	0.0%	0.0%	0.0%	0.0%	20.0%	0.0%	20.0%	0.0%	40.0%	0.0%	0.0%
EU	6.8%	3.4%	5.1%	6.8%	5.1%	15.3%	3.4%	10.2%	22.0%	22.0%	0.0%
Block 1: Cultural ES											
Country	1. NL-IBS	2. HIB	3. SGB	4. CSO/CA	5. SSS	6. SGMS	7. ST	8. RDF	9. RDA	10. LSGHM	11. other
Denmark	0.0%	0.0%	0.0%	0.0%	0.0%	50.0%	0.0%	50.0%	0.0%	0.0%	0.0%
Finland	25.0%	0.0%	0.0%	0.0%	0.0%	25.0%	0.0%	0.0%	16.7%	33.3%	0.0%
France	0.0%	0.0%	0.0%	12.5%	0.0%	17.5%	12.5%	0.0%	0.0%	25.0%	12.5%
Italy	5.0%	5.0%	5.0%	5.0%	5.0%	10.0%	0.0%	15.0%	30.0%	20.0%	0.0%
Romania	12.5%	0.0%	0.0%	12.5%	0.0%	0.0%	12.5%	25.0%	12.5%	25.0%	0.0%
Slovenia	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	16.7%	50.0%	33.3%	0.0%
EU	5.2%	1.7%	1.7%	5.2%	3.4%	3.4%	1.7%	17.2%	29.3%	31.0%	0.0%

24

Results

1. FGR management practices: EU level

Selected FGR management practice (frequencies) per Delphi round and ES category

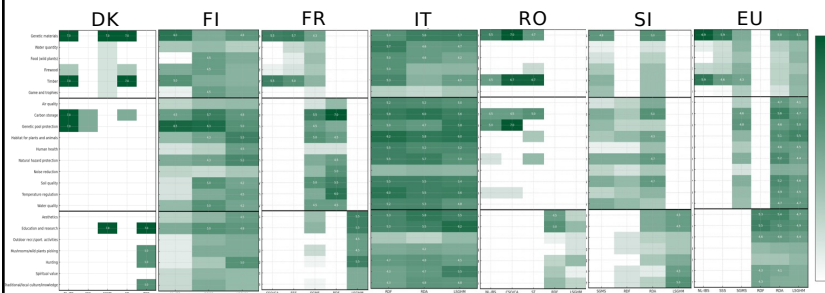
Block 1: Provisioning ES at the EU level											
Round	1. NL-IBS	2. HIB	3. SGB	4. CSO/CA	5. SSS	6. SGMS	7. ST	8. RDF	9. RDA	10. LSGHM	11. other
1	13.1%	6.6%	9.5%	9.5%	12.4%	9.5%	8.0%	6.6%	10.9%	13.1%	0.7%
2	15.7%	3.6%	6.0%	8.4%	13.3%	8.4%	4.8%	7.2%	10.8%	20.5%	1.2%
3	11.5%	4.9%	4.9%	6.6%	11.5%	11.5%	3.3%	6.6%	11.5%	24.6%	3.3%
Block 2: Regulating ES at the EU level											
Round	1. NL-IBS	2. HIB	3. SGB	4. CSO/CA	5. SSS	6. SGMS	7. ST	8. RDF	9. RDA	10. LSGHM	11. other
1	8.4%	6.9%	5.3%	6.1%	13.0%	2.3%	14.5%	19.8%	17.6%	0.0%	0.0%
2	7.2%	3.6%	2.4%	3.6%	9.6%	4.8%	16.9%	24.1%	24.1%	0.0%	0.0%
3	6.8%	3.4%	5.1%	6.8%	5.1%	15.3%	3.4%	10.2%	22.0%	22.0%	0.0%
Block 3: Cultural ES at the EU level											
Round	1. NL-IBS	2. HIB	3. SGB	4. CSO/CA	5. SSS	6. SGMS	7. ST	8. RDF	9. RDA	10. LSGHM	11. other
1	4.7%	0.8%	7.9%	3.1%	3.9%	10.2%	2.4%	18.5%	24.4%	23.6%	0.0%
2	2.5%	1.2%	2.5%	3.7%	4.9%	8.6%	1.2%	17.3%	32.1%	25.9%	0.0%
3	5.2%	1.7%	1.7%	5.2%	3.4%	3.4%	1.7%	17.2%	29.3%	31.0%	0.0%

1. NL-IBS: Novel low-input breeding strategies; 2. HIB: High intensity breeding; 3. SGB: Seed/Gene banks; 4. CSO/CA: Conservation seed orchards/clonal archives; 5. SSS: Selected seed stand; 6. SGMS: Silviculture of genetically mixed stands; 7. ST: Selective thinning; 8. RDF: Rescue of declining forests; 9. RDA: Restoration of devastated areas; 10. LSGHM: Landscape-scale genetic heterogeneity management

25

Results

2. FGR management practices and ES: country & EU levels



1. NL-IBS: Novel low-input breeding strategies; 2. HIB: High intensity breeding; 3. SGB: Seed/Gene banks; 4. CSO/CA: Conservation seed orchards/clonal archives; 5. SSS: Selected seed stand; 6. SGMS: Silviculture of genetically mixed stands; 7. ST: Selective thinning; 8. RDF: Rescue of declining forests; 9. RDA: Restoration of devastated areas; 10. LSGHM: Landscape-scale genetic heterogeneity management

28

Most valued ES

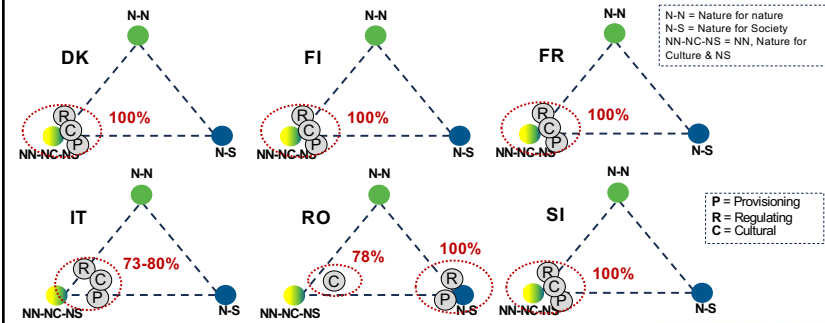
- **Provisioning:** Timber+Firewood, Genetic materials
- **Regulating:** Carbon Storage, Genetic Pool Protection, Protection against Natural Hazards
- **Cultural:** Education and Research



29

Results

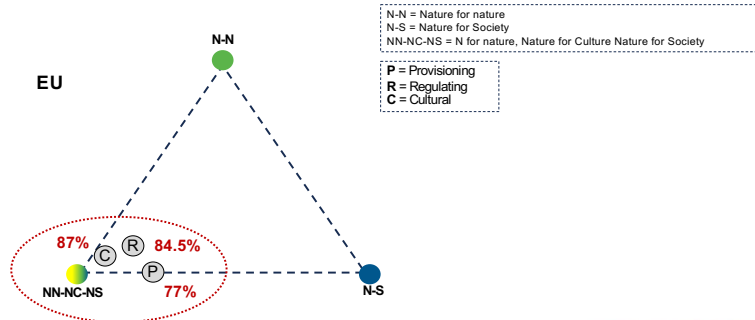
3. FGR management practices and ES: future scenarios



30

Results

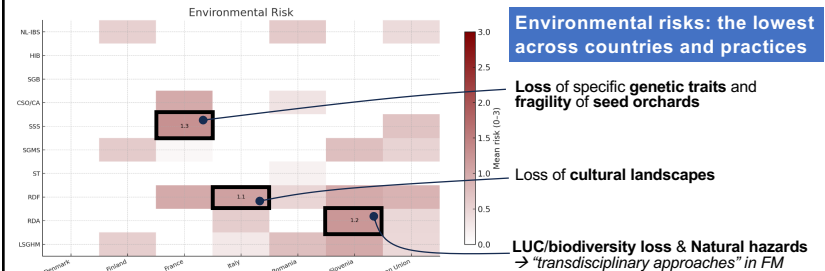
3. FGR management practices and ES: future scenarios



31

Results

4. FGR management practices, risks & mitigation: Environmental

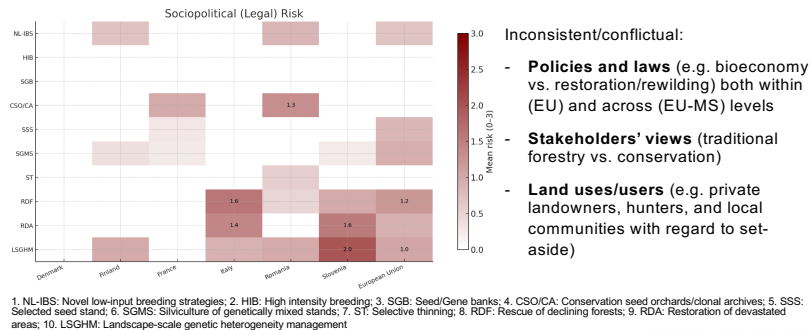


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33

Results

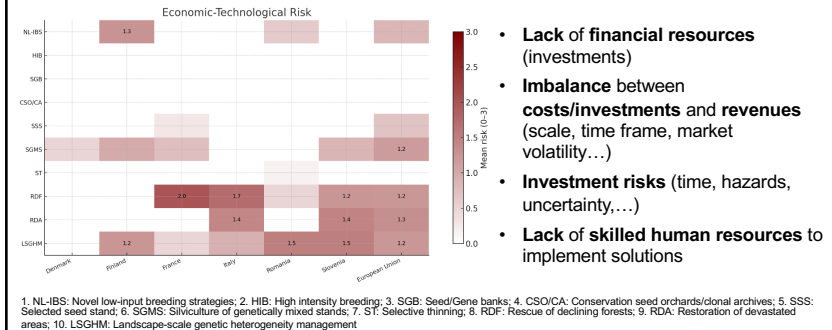
4. FGR management practices, risks & mitigation: Sociopolitical



- Inconsistent/conflictual:
- **Policies and laws** (e.g. bioeconomy vs. restoration/rewilding) both within (EU) and across (EU-MS) levels
 - **Stakeholders' views** (traditional forestry vs. conservation)
 - **Land uses/users** (e.g. private landowners, hunters, and local communities with regard to set-aside)

Results

FGR management practices, risks & mitigation: Economic-Technological



- **Lack of financial resources** (investments)
- **Imbalance between costs/investments and revenues** (scale, time frame, market volatility...)
- **Investment risks** (time, hazards, uncertainty,...)
- **Lack of skilled human resources** to implement solutions

Final considerations (1/2)

- Different FGR management practices operate at complementary scales, from genetic to landscape → **heterogeneity** of practices → **multifunctionality**
 - **@EU level**: 4 blocks of practices (breeding, stand restoration, landscape-scale management) cover most of the ES
 - **@country level**: diverse patterns
 - IT and SI → restoration
 - FI → more heterogeneity
 - RO → breeding strategies
 - **Provisioning & Regulating ES** → stand and landscape practices
 - **Cultural ES** mostly landscape-scale practices
- 38

Final considerations (2/2)

- **Most valued/considered ES**
 - Provisioning**: Timber + Firewood, Genetic materials
 - Regulating**: Carbon Storage, Genetic Pool Protection, Protection against Natural Hazards
 - Cultural**: Education and Research
 - **Future perspective**: experts predominantly selected a **multifunctional** scenario
 - **Sociopolitical and economic-technological risks** associated with FGR management practices **more relevant than environmental ones**
- 39

WP7

Team

































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40